INVENTORIES OF APPARATUS AND MATERIALS FOR TEACHING SCIENCE

VOLUME I

PRIMARY, SECONDARY AND VOCATIONAL SCHOOLS

UNESCO

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VOLUME I

PRIMARY, SECONDARY AND VOCATIONAL SCHOOLS

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PREFACE

Educational and cultural rehabilitation has been, and still is, one of the chief problems confronting the post-war world. Educational and cultural centres, such as schools, colleges, laboratories, libraries, museums, were either destroyed or looted on a large scale during the last war. The enormous task of restoring them to their pre-war conditions is far from being completed. In addition there has been an awakening to the urgent need for expanding all forms of education, especially in underdeveloped regions.

Everywhere there is an increasing awareness that it is important to provide greater facilities for teaching science and technology. This is because science and technology have produced immense changes in man's ability to understand nature's mysteries and to control and utilize its forces for his purposes. Wherever peoples are confronted with low standards of life and are trying to improve them, they turn to science and technology.

To implement the plans that have been prepared for the adequate teaching of science in schools and colleges in the war-damaged and the underdeveloped regions is admittedly a long-range enterprise. Any guidance towards improved techniques in this field of education would surely be of great help to the authorities concerned. For this reason Unesco is presenting, together with the corresponding curricula, a series of inventories of apparatus and materials for teaching science at all levels. It is hoped that these publications will be useful to educators as reference manuals for selecting essential equipment from the lists commonly used in some of the leading countries. For clarity the lists are related to the corresponding curricula. To develop the information given in the Inventories, Unesco is now preparing a series of ten handbooks for science teachers in underdeveloped countries. By diffusing comparative information of this kind on the training of students, the Inventories should contribute also to bringing about equivalence of degrees and diplomas in science and engineering, irrespective of the universities and institutions where they are awarded.

Such an approach to the problem of scientific reconstruction was initiated by the Conference of Allied Ministers of Education which was first held in London in 1943. The Science Commission set up by that conference issued in 1945 a limited set of inventories of basic scientific equipment as an *aide-mémoire* to the governments of occupied Europe, to assist them in rehabilitating scientific education.

Unesco Inventories are being published in three volumes and in several languages; Volume I groups information bearing on Primary, Secondary and Vocational Schools; Volume II, on Universities; and Volume III, on Technical Colleges. While prices of items of equipment are mentioned in U.S. dollars whenever possible in the Inventories, these should be taken as indicative rather than exact, owing to the prevailing fluctuations both in the cost and the quality of available apparatus. However, when a specific request arises for more detailed and up-to-date information for installing a school or a college laboratory, Unesco will attempt to furnish an answer.

The Inventories have been compiled from reports submitted by experts from six countries generally considered to lead in the field of science education. Unesco expresses its thanks to Marcel Peschard, France; S. W. Tromp, the Netherlands; Gunnar Hambraeus, Sweden; Pierre Speziali, Switzerland; J. P. Stephenson and R. Thurlow, United Kingdom for submitting reports at short notice; and its appreciation to Norman R. D. Jones, President of the National Science Teachers Association of the United States, for his generous permission to make use of the valuable information published by the Association on " Science course content and teaching apparatus used in schools and colleges of the United States ".

Unesco is especially indebted to Dr. Ellsworth S. Obourn, United States, for this revision of the first edition on the basis of his experience as technical assistance expert in Thailand and in the light of changed conditions and cost of equipment since the original printing.

PART ONE

PRIMARY SCHOOLS

1. INTRODUCTION

The present-day teaching of elementary science in primary schools is determined by two factors: the cultural and educational value of science, and the development of the child's ability to acquire knowledge. The equipment for the teaching of science listed in these Inventories is correlated to a curriculum which is based on these modern concepts. More important than the curricula are, of course, the methods of teaching science which are derived from the new findings on child psychology. These methods are not discussed in this publication but will form the subject of another Unesco series now in preparation: "*Guides to science teachers in underdeveloped countries*".

The equipment presented here is meant for demonstration and for performing simple experiments in teaching elementary science along the lines of the course content indicated on page 12. This course content briefly outlines a curriculum for the guidance of primary schools. The extent of such a study would depend on various factors—the competence of the teacher, the time allotted to the subjects, the methods employed, local conditions and so on. However, the important point in regard to this study programme is that it is currently followed in the countries from which the reports are obtained and is not something derived from pure theory.

The time required for implementing this study programme, i.e. the duration of the primary cycle of education, varies from country to country. On the average, a period of seven years, say from 5 to 12 years of age, is considered necessary for adequate training. As to the time devoted to teaching science, it varies from ½ hour to 3 hours per week depending, generally, upon the age of the children.

A suggestive distribution of subject matter for study according to age grouping is given on page 12. The apparatus and supplies listed are considered necessary and sufficient for performing the requisite variety of simple experiments implied in the course content. The stress in any modern approach to science teaching in primary schools is on the provision of opportunities for children to take an active part in the lessons, i.e. to guide them to teach themselves. The main objectives at the primary level are to train the pupils to observe, to relate and to correlate natural phenomena accessible to their boundless curiosity and to their rapidly developing intelligence, and to convey a comprehensive view of nature as a whole. This new approach is further characterized by the use of science and scientific methods to revitalize the educative processes for children. For a clearer appreciation of this point of view, the reader is referred to Appendix 4, which reproduces the recommendations issued by the Twelfth International Conference on Public Education convened in Geneva by Unesco and the International Bureau of Education (IBE) during July 1949, in which official delegations from 47 countries participated.

In most schools, science is taught in the regular classroom by the regular class teacher, using selected equipment from a central store-room. However, in some schools, a special room is provided which becomes the " science centre " for the whole school, with facilities for simple experiments by children under the supervision of the teacher.

The Inventories list both the permanent equipment and consumable supplies adequate for a primary school of 200 pupils. The consumable supplies are estimated as sufficient for one school year.

The most important aspect of teaching science at the primary school level is the use of simple apparatus, especially that made in the class by the teacher in collaboration with the pupils. For more detailed information on this point, teachers are advised to consult such publications as: *Suggestions for science teachers in devastated countries*, prepared by J. P. Stephenson and published by Unesco; a series on "*Teaching elementary science*" published by the Federal Security Agency Office of Education, U.S. Government Printing Office; and *Introduction to natural science in primary schools* prepared by the Twelfth International Conference on Public Education (IBE Publication No. 111).

The Inventories also include equipment for audio-visual education, the usefulness of which is being increasingly recognized. The importance of radio should be stressed in view of the excellent results already obtained in many countries, and especially by the School Broadcasting System of the British Broadcasting Corporation in the United Kingdom.

2. COURSES OF STUDY FOR PRIMARY SCHOOLS

A. Course Content

General facts about the environment	Distinction between animate and inanimate objects. Recognition of natural things and things made by man.
Inanimate matter	Rocks and soil. Raw materials. Air and water. Wind, rain. States of matter: general properties of solids, liquids and gases. Observations supplemented by measurements. Measurement as a tool of science. Length, weights. Value of widely accepted standards. Metric system Scales.
Physical changes in matter	Melting, solidification, boiling, evaporation, condensation. Expansion of solids and liquids. Heat, temperature, thermometers.
Chemistry	Combustion, combustibles. Air, oxygen, CO_2.
Electricity	Existence of electricity and magnetism. Compass, lightning.
Animate entities Plants	Description. Fruits and seeds. Functions of stem, root and leaves. Broad classification. Poisonous plants.
Animals	Description. Domestic and wild. Broad classification.
The Human Body	Description. Main functions: digestion, circulation, respiration, elimination. Common ailments. Diseases. Cleanliness, hygiene. Public health, first-aid.

B. Grouping by Age

A tentative distribution among the different age groups might be the following:

First age group:	5-7 years	Nature study. Simple facts about rocks and soil. Common plants. Domestic animals.
Second age group:	7-9 years	Air and water. More about animals and plants. The human body.
Third age group:	9-11 years	States of matter. Measurements of length, weights. More about the human body.
Fourth age group:	11-12 years	Changes in matter. Combustion, heat. Simple facts about electricity and magnetism. Classification of plants and animals. Hygiene.

C. EXPERIENCES WHICH SCIENCE IN THE PRIMARY SCHOOL SHOULD PROVIDE

1. Atmosphere
   - What the air is made of.
   - The atmosphere pushes on us from all directions.
   - The atmosphere contains water.
   - The atmosphere contains germs.
   - Rain, snow, sleet, hail, frost, dew, etc.
2. Water
   - The water cycle.
   - Water is necessary for life.
   - Some germs live in water.
   - Means of purifying water.
3. Rocks and soil
   - Soil is derived mostly from rocks.
   - Kind of soil.
   - Water and wind may carry the soil away.
   - Coal, oil, gas and other products come from beneath the soil.
4. Plants
   - The growth of plants. Plants must have the necessary chemical elements; plants must have water; plants must have sunlight; roots grow down, shoots grow up.
   - There are many kinds of plants.
   - Plants grow in communities.
   - Man has some control over plant communities.
   - Man's dependence upon plants.
5. Animals
   - Feeding habits.
   - Breeding habits.
   - Plants and animals are interdependent.
   - Man's dependence upon animals.
6. The area of health
   - The human body as a machine. Consumption and use of energy; elimination of waste.
   - Cause, treatment and prevention of common ailments; headaches, stomach disorders, colds.
   - Communicable diseases. Causes, symptoms, prevention.
   - Public health. Personal cleanliness, clean playgrounds, clean streets, clinics.
7. Energy
   - The sun is a source of energy.
   - Kinds of energy.
   - Energy may be changed from one kind to another.
   - Man's use of energy.
8. Electricity and magnetism
   - Static.
   - Current.
   - Production.
   - Distribution.
9. Machines
   - Simple.
   - Compound.
10. The solar system
    - Relationship of the earth and sun.
    - Relationship of the earth and other planets.
    - Other bodies in the solar system.
11. The stellar system
    - Bodies beyond the solar system.
    - The nature of stars.
    - Man's use of knowledge about the stars.
    - Space.

3. EQUIPMENT (200 pupils)

A. Apparatus

Quantity	Item	Total cost in dollars
2	Aquaria	18.00
2	Balances, Roberval, 5 kg	20.00
3	Balances, spring, 0-250 g	5·25
3	Balances, srping, 0-500 g	5·25
1	Ball and ring apparatus	2.00
2	Balls, tennis	1.00
2	Balls, ping pong	.60
2	Balls, steel, 1 in diam	·50
2	Balls, wood, 1 in diam	·30
1	Barometer, aneroid	9.00
1	Barometer, mercurial, Fortin	27·50
6	Beakers, Pyrex, 100 ml	1.80
6	Beakers, Pyrex, 250 ml	1.80
6	Beakers, Pyrex, 600 ml	2.40
2	Bells, electric door	1.80
1	Block and tackle double with rope	7.00
2	Boxes, insect, glass top	6.00
3	Burners, alcohol	4·50
3	Burners, bunsen	2.25
3	Buttons, push	.60
1	Cage, animal	18.50
1	Can, sprinkling, 5 gal	2.00
12	Cells, dry	9.00
6	Cells, flashlight	·75
12	Charts, human body, animals, plants	20.00
6	Clamps, burette	2.50
6	Clamp holders, right angle	2·75
4	Clamps, universal support	2.50
1	Colour top, toy	·50
2	Compasses, pocket	1.50
1	Convection box	3.00
1 set	Cork borers	2.00
2	Crucibles, porcelain and covers	·75
2	Dishes, evaporating, porcelain	.60
6	Dishes, Petri, Pyrex, 100 mm diam, 15 mm deep	3.20
1	Flashlight	1.25
6	Flasks, Pyrex, 500 ml	2.40
6	Flasks, Pyrex, 125 ml	1.80
2	Funnels, Pyrex, 75 mm diam	1.30
1	Galvanometer, student type	13.50
1	Galvanoscope	2.50
2	Gauze, wire, asbestos centre	.30
1	Germination box	5.00
1	Glass, reading	2.00
6	Glasses, watch, 60 mm diam	.48
3 sheets	Glasses, window, 30 × 30 cm	1.50
6	Glass tumblers	.72
6 pieces	Glass, ground 10 × 10 cm	.60
	Carried forward	220.45

Quantity	Item	Total cost in dollars
	Brought forward	220.45
6	Glass bottles, soda	.30
1	Globe, world	7.00
1	Graduate, 100 ml	2.00
1	Gyroscope, toy	1.50
1	Heater, electric	8.25
1	House, ant observation	6.00
1	Induction coil, automobile	1.75
4	Jars, battery, small	2.40
4	Jars, battery, large	5.60
6	Lamp chimneys, student type	2.50
1 set	Lenses, demonstration set	8.00
3 pieces	Lodestone	.90
2	Magnets, bar	1.00
1	Magnet, horseshoe	.50
1	Magnet U-shaped	.75
1	Magneto generator, hand	12.50
2	Magnifiers, tripod	3.20
12	Medicine droppers	.40
3	Mercury wells	1.50
3	Metre and yard sticks	2.25
1	Microscope Band 4 " Little Gem "	24.00
1 set	Minerals	7.00
3	Mirrors, cylindrical, concave-convex	2.20
3	Mirrors, plane	.50
1	Motor, St. Louis, complete with field coil	6.50
1	Model of automobile cylinder	20.00
1 pkg	Needles, darning	.50
2	Needles, magnetic	.30
2	Pads, wool and silk for friction rod	1.40
3	Pots, flower with saucers	.60
3	Prisms, glass 60°	1.45
6	Pulleys, bakelite, single	3.00
4	Pulleys, bakelite, double	2.40
2	Pulleys, bakelite, treble	1.40
1	Pump, hand, pressure and vacuum	6.00
1	Rod, ebonite	.40
1	Rod, glass	.50
6	Sockets, miniature light	.72
4	Spoons, iron tea	.40
1	Steam engine, toy	9.00
1	Steam turbine, toy	9.00
6	Support stands, complete with rings	13.50
2	Switches knife, single pole, miniature	.30
2	Switches knife, double pole, double throw, miniature	.40
4	Switches knife, double pole, double throw, large	1.50
2	Telegraph keys	6.00
2	Telegraph sounders	10.00
2	Telephone receivers	6.00
2	Telephone transmitters	5.00
1	Terrarium, glass	16.75
2	Thermometers, chemical, mercury	3.00
4	Thermometers, alcohol, coloured	6.00
1	Thermometer, maximum-minimum	4.50
1	Top, mechanical	.50
3	Tripods, iron 6 inch	3.00
3	Tubes, barometer, 80-90 cm	3.60
12	Tubes, test, Pyrex, 18 × 150 mm	.72
3	Tuning forks, C=256, E=320, C=512	5.85
2	Tuning forks, mounted on sound boxes G×384	15.00
	Carried forward	487.64

Quantity	Item	Total cost in dollars
	Brought forward	487.64
1 set	Units, length, surface, volume, metric	2.00
1	Volt-ammeter, pocket type	2.50
1 set	Weights, metric, universal hook	6.75
1 set	Wood samples	6.00
	Total	504.89

B. Tools

3	Blades, hack saw	.40
2	Forceps, iron	.50
1	Iron, soldering, electric	1.50
1	Jack knife, Boy Scout	2.50
1	Saw, adjustable, hack	1.50
1 pr	Scissors, 5 in	.75
1 pr	Shears, for cloth	1.00
1 pr	Shears, for tin	2.00
1 set	Tools, 20 in chest	30.00
	Total	40.15

C. General Supplies

12	Balloons, toy	.60
12 sheets	Blotting paper	.30
6	Bulbs, flashlight	1.20
6	Bulbs, slide projector	9.00
12	Candles, large	.40
1 box	Candles, birthday	.20
2 tubes	Cement, household	.60
10 kg	Clay, modelling	7.50
1 box	Coloured chalk	.35
1 box	Coloured pencils	1.00
1 bag	Corks, assorted	.85
3	Cups and saucers	.75
4	Cups, tin	.60
1 pkg	Filter paper	.30
1	Glass tubing cutter	.85
1 bottle	Glue	.45
1 box	Labels, gummed	.20
2 vials	Litmus paper, blue and red	.30
1 box	Nails, assorted	1.00
3	Pans, assorted sizes	1.50
1 pkg	Parawax	.30
250 g	Pins, common	1.00
1 box	Rubber bands, assorted	.75
1 sq yd	Rubber sheeting	2.70
1 box	Screws, assorted	.30
1 kg	Solder	1.60
500 g	Solder flux	.40
1 kg	Stoppers, rubber assorted	3.10
1 ball	String	.75
1 box	Tacks, iron	.20
1 spool	Thread, linen	.60
2 kg	Tubing, glass, diam 6, 10, 12 mm	3.00
10 m	Tubing, rubber, diam 3 and 6 mm	3.00
250 g	Wax, sealing	.40
1 spool	Wire, copper, bare	.50
1 kg	Wire, copper, bell	2.00
1 doz	Wicks, for alcohol lamps	.25
	Total	48.80

D. Chemicals

Quantity	Item	Total cost in dollars
500 g	Acetic acid 36%	.50
500 g	Agar agar	2.00
500 g	Alcohol methyl	.75
500 g	Alum, potassium, pure	.75
500 g	Ammonium chloride, pure	.75
500 g	Ammonium dichromate, pure	1.20
500 g	Ammonium hydroxide, pure	.60
1 jar	Beef extract	.70
500 g	Boric acid, pure	.40
2500 g	Calcium carbonate (marble chips)	1.70
500 g	Calcium phosphate, pure, monobasic	.35
100 g	Camphor	.70
500 g	Carbolic acid	.72
1000 g	Copper sulphate, tech.	.70
500 g	Copper turnings, fine	1.00
500 g	Ferrous sulphate, pure	1.10
1000 g	Fehling's solution A and B 500 g each	1.10
500 g	Glycerine	1.00
1500 g	Hydrochloric acid, pure	2.55
100 g	Iodine crystals, resublimed	1.60
500 g	Iron filings, medium	.40
500 g	Lead turnings, fine	.70
1000 g	Lead, sheet 3 mm	1.20
1 roll	Magnesium, ribbon	.60
500 g	Magnesium sulphate, pure	.80
500 g	Manganese dioxide, powder	.50
6 kg	Mercury, metal	49.50
200 g	Peptone	3.00
100 g	Phosphorus, red	.45
100 g	Phosphorus, yellow	.60
1000 g	Potassium chlorate, cryst.	1.60
500 g	Potassium chloride, pure	.90
500 g	Potassium permanganate, pure	.65
500 g	Sodium bicarbonate, commercial	.30
500 g	Sodium chloride, commercial	.20
500 g	Sodium hydroxide, pellets	.80
500 g	Starch, corn	.40
1000 g	Sugar, cane	.50
500 g	Sulfur, powder (flowers)	.45
500 g	Sulfur, roll	.45
500 g	Tin turnings	2.40
500 g	Wood charcoal, lump	.50
500 g	Zinc, mossy	.60
500 g	Zinc, sheet	1.00
	Total	88.67

E. Audio-visual Aids

1	Projector, motion picture with amplifier and speaker	350.00
1	Projector, filmstrip	75.00
1	Projector, lantern slide	80.00
1	Radio set	50.00
1	Screen	15.00
	Total	570.00

F. MISCELLANEOUS MATERIALS TO BE SUPPLIED LOCALLY

Cloth, various kinds
Electric bulbs, used
Electrical equipment, used
Metal scraps
Musical instruments
Paints

PART TWO

SECONDARY SCHOOLS

1894

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SENIOR BA

1. INTRODUCTION

Secondary education provides for the training of youth from about 13 to 18 years of age inclusive, i.e. from the end of primary education up to the universities, technical colleges or specialized institutions. Furthermore, it provides the pupils with opportunities for discovering and testing their special abilities so as to enable them to choose their future careers with confidence.

Science courses in secondary schools provide for more factual information and for greater appreciation of the method of acquiring scientific knowledge. Following closely the students' mental progress, efforts are continued along the same lines as in the primary schools for developing a scientific attitude towards life. They include more elaborate experiments, synthesis of results, use of general methods and their application to various problems of technical, economic or social nature.

The general approach to science teaching, which is more a " science education" than the conventional " science instruction " has greatly affected the usual methods of teaching. A new course called " general science " has been developed during the past few decades in the U.S.A. and in other countries; this is an integrated effort to strengthen the place of science in general education, in view of the predominant role that science is assuming in the modern world.

For those students who wish to study science further, the secondary schools provide separate and specialized courses in mathematics, physics, chemistry and biology.

The same general pattern as for primary schools has been followed in presenting the Inventories relevant to secondary schools, i.e. the course content precedes the listed equipment, thus maitaining a direct correlation between them. On page 22 is given a typical course content of general science followed by the corresponding list of equipment as reported from the U.K.

Physics and chemistry are taught chiefly in laboratories. This fact is taken into account in the presentation of the course content, where each group of topics to be studied has a parallel column of suggested experiments. The necessary equipment for each discipline follows the course content. The chemicals needed for teaching physics and biology may be obtained from the chemistry laboratory. Similarly, the tools which are listed in the equipment for physics can be used for teaching general science, chemistry and biology.

Chemistry teaching calls for a special category in the list of apparatus and supplies, as provision has to be made for individual locker equipment for which students are responsible.

The biology courses differ somewhat from those in physics and chemistry and the method of teaching might be a combination of the lecture-demonstration-discussion type along with as much individual and group laboratory work as possible. The course content given on page 60 is not exhaustive and is followed by the needed equipment and supplies.

In the Inventories, the equipment listed for different subjects is generally considered sufficient for a class of about 40 pupils and the supplies for one school year. The audio-visual appliances for a secondary school would be the same as those already given for primary schools and therefore have not been listed once again.

An important aspect of teaching science is the use of simple apparatus made in the classroom by the teacher with the collaboration of the pupils. The maintenance and repair of simple instruments thus built should preferably be entrusted to the pupils themselves. In the bibliography some publications are listed which give useful suggestions for the construction of simple and " home-made " apparatus.

Extra-curricular and out-of-school activities constitute a very important development in the provision of opportunities for the study of science by young pupils. In Appendix 6 a list of youth organizations is given along with the recommendations made by Science Club leaders at an international meeting convened by Unesco in July 1949.

2. GENERAL SCIENCE

The following quotation gives a clear idea of what is meant by a general science course and how it is taught by the " Topic Method " in the U.S.A.:

" As a common practice, this subject is offered either over a period of three years in a junior high school or as a one-year offering in the ninth grade of a four-year high school. General science is the most nearly universal of the science courses studied by pupils in the public schools of the United States.

" General science, as the name implies, is a course designed to give pupils an opportunity to become acquainted with the important scientific generalizations as these are related to content, methods, and attitudes. As the course outline indicates, the course involves a study of many areas, each of which, at a later stage, represents a speciality. Thus the study tends to orient the pupil to the whole of science and at the same time provides a basis for pupils to consider the making of plans for further studies in the sciences.

" The instruction is characteristically a study of experimental demonstrations performed by the teacher, often with the assistance of pupils. Textbooks provide additional information, and visual aids are used as opportunities for more extensive observations. Many teachers encourage their pupils to plan and develop projects which call for library study, experimentation, and the preparation of reports. Due to the assignment of classes to general types of classrooms and to the use of teachers who are relatively uninformed in the areas covered by general science, much instruction may be done by textbook reading and class discussion.

" . . . Some schools allocate selected topics to each of the three grades of the junior high school. Some schools relate the basic science to such functional areas as transportation, communication, health, conservation, and the like. Still other schools arrange a cyclic pattern in which certain related topics are developed so as to build up from year to year, for example, air, weather, aviation. Then too, some schools follow a core development in which science finds a place along with subject matter from other discipline. The degree of detail included for any one topic will depend upon the time, the facilities available and the preparation of the teacher". [1]

A. Course Content

(*a*) *Bodies at rest and in motion*

The experimental study of the lever, of the equilibrium of a body under two forces, of the relation between time and distance for a body sliding down an inclined plane, or for two bodies connected by a string passing over a pulley, of the impact of two inelastic bodies moving in the same line. The ideas of velocity, acceleration, force, mass, momentum, kinetic and potential energy, work and power in so far as these afford a convenient description of the results of the foregoing experimental study.

The description of the apparent motion of the sun, moon, stars and planets in terms of the Copernican system.

Qualitative treatment of the law of gravitation as exemplified by planetary motion, weight, and the attraction of two small bodies.

Simple discussion of the mechanics of the crow-bar, wedge, screw, block and tackle.

(*b*) *Energy*

Heat as a form of energy. Sources of heat: sun, fuels (including food), electricity, friction. Transformation and conservation of energy. Thermal expansion of solids and liquids and gases treated qualitatively—applications and consequences in everyday life. Thermometers, C and F scales, and determination of fixed points. Clinical thermometer. Expansion of water on freezing and its consequences in nature. Units of heat. Simple calculations on cost of gas, including ability to read gas meter. Meaning and comparison of thermal capacities and consequences in nature. Change of state. Meaning of latent heat. Everyday examples of cooling by evaporation. Fusion. Qualitative treatment of vapour pressure, dew, mist, and atmospheric moisture. Influence of pressure and dissolved substances on boiling and freezing points of liquids.

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[1] *Science course content and teaching apparatus used in schools and colleges of the United States*. U.S. Scientific Export Association Inc., 50 Broadway, New York, N.Y., 1947, 186 pp.

Transference of heat. Conduction, with emphasis on heat insulation and other everyday applications. Convection, domestic hot-water system. Radiation, good and bad radiators and absorbers in everyday life.

Luminous and non-luminous bodies. Reflection at plane surfaces, periscope. Refraction. Experimental determination of focal length of convex lenses and concave mirrors (knowledge of formulae is not required). Uses of lenses and mirrors in everyday life. Graphical methods of determining position and size of an image. Refraction by a prism. Spectrum formed from white light. Colour. Importance of absorption of light energy by chlorophyll.

Experiments to show that sound is due to vibration and that a material medium is necessary for its propagation. Elementary idea of the nature of a sound-wave and its effect on the ear. Velocity of sound in air by direct measurement; echoes. Variation of pitch with length and tension of a vibrating string and with length of an air column.

Elementary properties of magnets; permanent and temporary magnets. Simple treatment of the earth as a magnet. Qualitative treatment of magnetic and thermal effects of an electric current and simple practical applications. The electric bell. Practical units of measurement. Ohm's Law (no verification) and its application to simple circuits, the whole to be treated from the standpoint of the safe and efficient use of electricity in everyday life as illustrated by choice and care of appliances (e.g. correct voltage for household supply, correct wattage for purpose required, types of lamps, etc.), cost of using electrical apparatus, precautions necessary to avoid electric shock, fuses. Electro-magnetic induction as an example of the conversion of mechanical into electrical energy. Simple cell, polarization, dry battery. Chemical effects of a current. Electrolysis. Electro-plating. Storage cell, the use and care of the lead accumulator.

(*c*) *Matter*

Classification of matter as solids, liquids and gases. Simple explanation of their properties in terms of molecular movement.

Density; its determination by direct measurement of weight and volume. Relative density; determination of that of a fairly large solid by the principle of Archimedes, and of liquids by the density bottle. Flotation in liquids and air. Simple barometer. Lift-pump and force-pump.

Simple experiments to illustrate surface tension, capillarity, diffusion, osmosis. Importance of these in natural phenomena.

Elements, compounds, and mixtures. Constancy of composition of compounds. Dalton's atomic theory in so far as it assists in giving a mental picture of a chemical reaction.

The air and its main constituents. Special importance of oxygen in relation to burning, rusting, respiration. Proportion of oxygen in air (slow oxidation of phosphorus or rusting of iron filings). Its isolation by action of heat on mercuric oxide, potassium permanganate and potassium chlorate. Properties of oxygen. Combustion of carbon, sulphur, phosphorus. General properties of acidic oxides.

Importance of water as a solvent; evaporation and crystallization. Influence of temperature on solubility in water. Importance in nature of solubility of oxygen and carbon dioxide.

Man's discovery of bronze and iron by simple smelting processes. Extraction of tin and iron by reduction. Characteristic properties of metals. Uses of steel and of important alloys (brass, bronze, solder).

Liberation of hydrogen from water and acids by metals. Synthesis of water by burning hydrogen and by reduction of metallic oxides. General properties of acids and of bases. Formation of salts.

Limestone and other forms of calcium carbonate. Reactions of limewater and carbon dioxide. Formation of calcium bi-carbonate, its effect on water and its importance as a source of calcium carbonate for shells.

Carbon as a fundamental constituent of organic matter. Carbon dioxide produced by most ordinary combustible substances, including food materials. Other sources of this gas, such as fermentation. Production by action of acid on a carbonate. The carbon cycle in nature. Everyday uses of carbon dioxide.

Carbon monoxide, its physiological effect and the conditions under which it is likely to be produced in everyday life. Its use as a fuel and as a reducing agent.

Carbohydrates, proteins, and fats as food materials. Meaning of calorific values of fuels and foodstuffs.

Sulphur (excluding allotropy) and its relation to sulphuric acid. Manufacture of sulphuric acid (details not required). Preparation of sulphur dioxide by the burning of sulphur. Its use in bleaching and fumigation.

Common salt, chlorine, hydrochloric acid. Importance of chlorine in sterilization of water and in bleaching depending on its affinity for hydrogen. Bleaching-powder as a disinfectant.

Saltpetre. The nitrogen problem and how it has been solved as an example of the influence of chemistry on world affairs. Haber process (no technical details). Ammonia. Nitrogen cycle. General account of the importance, in everyday life, of nitric acid in the manufacture of fertilizers, dyes, and explosives.

(*d*) *Life*

The characteristics of living things as revealed by the observation of familiar plants and animals.

The recognition of these characteristics in herbaceous flowering plants, and in a mammal, e.g. the rabbit, with reference to man where appropriate. Their physiology and simple anatomy (so far as this can be observed by the unaided eye or the hand-lens) under the following headings:

(i) Respiration: the source, liberation and utilization of energy; gaseous exchanges. Respiration mechanism, internal and external respiration in mammals.

(ii) Nutrition: the raw materials used by plants, absorption of water and dissolved substances, photo-synthesis and further elaboration of food, food storage and digestion.

The nature and sources of animal food, food capture, ingestion, digestion, absorption, assimilation; inorganic salts and vitamins and their importance to health in man.

(iii) Excretion: the nature and origin of excretory products, excretory products, excretory mechanisms.

(iv) Irritability: responses of main stems and roots to gravity and light. The central nervous system (in outline only); simple reflex arc. Sense organs in general; eye.

(v) Support and movement. Turgidity and its role in support. The general features and functions of the mammalian skeleton; the skin and its functions.

(vi) Reproduction: definition of sexual reproduction. Structure of a simple flower (e.g. buttercup) and its pollination. Wind and insect pollination. Fertilization (excluding details of the embryo sac).

Reproductive system and reproduction in the mammal.

(vii) Development and growth: the embryo (plant and animal) and its source of food. The seed, germination of pea or bean.

Functions of the placenta (excluding details of the foetal membranes). Parental care.

The contrast between living organisms and non-living material—the amoeba; protoplasm as the basis of life. Differences between animals and plants, dependence of animals on green plants.

Special methods of nutrition. Saprophytism and parasitism.

Elementary study of the formation, composition and properties of soil with simple experiments on capillarity, water-holding capacity and drainage. Earthworms, their habits in relation to the formation of vegetable mould. Natural history (very elementary) of any one habitat, e.g. waste ground, garden, town park, hedgerow, ditch, pond, wood, meadow, seashore.

Mode of life, and life history of an insect (e.g. butterfly) and of a frog.

Biology and man: bacteria, useful and harmful. Preservation of food. Insects as carriers of disease (house-fly and mosquito).

B. Equipment for General Science (40 pupils)

(a) *Apparatus*

Quantity	Item	Total cost in dollars
1	Air globe, for weight of air	5.00
1	Ammeter, triple range, DC 5/25/25	36.50
2	Aquaria	18.00
1	Balance, demonstration	3.50
1	Balance, spring (dairy scale) 0-1000 g	7.50
12	Balances, spring, 0-2000 g	21.00
6	Balances, spring, 0-500 g	10.50
1	Balance, spring, English and metric scales, 15 kg	5.50
10	Balances, platform, triple beam, agate bearings, capacity 1610 g	180.00
12	Balloons, rubber	1.20
1	Ball and ring apparatus	1.75
36	Ball bearings	3.00
1	Bar compound, iron and brass	.60
1	Bar and gauge	2.20
1	Barograph	150.00
1	Barometer, aneroid	13.50
1	Barometer, mercury, Fortin type	27.50
4	Barometers, tubes 80-90 cm in length	3.50
6	Baths, water, with rings	13.50
96	Beakers, Pyrex, 100 ml	25.02
96	Beakers, Pyrex, 250 ml	24.68
48	Beakers, Pyrex, 400 ml	14.88
48	Beakers, Pyrex, 500 ml tall	20.16
12	Beakers, Pyrex, 1000 ml	8.88
1	Bell, electric, large, for demonstration	25.00
10	Bells, electric, small	8.50
1	Bell jar, bladder type	9.00
1	Bell jar, no tubulure, 3 l	7.00
1	Bell jar, tubulure, 3 l	10.50
1	Bell jar, open flanged	6.50
1	Bell jar, for barometer, tube	13.50
1	Bench, optical with lenses, mirrors and other accessories	60.00
12	Blocks, glass, 10 × 5 × 2.5 cm	13.50
12	Blocks, wood, 8 × 8 × 4 cm	1.44
1	Block and tackle, with rope	3.50
10	Bobs, pendulum, lead	2.40
6 sets	Borers, cork, with handles	7.20
15	Bottles, 25 ml	.90
6	Bottles, cast iron for breaking (ice bomb)	9.00
24	Bottles, reagent, 175 cc, stoppered	7.20
12	Brushes, test tube	.75
6	Brushes, beaker	2.40
12	Bulbs, flashlight	1.80
2	Bulbs, electric, carbon filament, 16 CP	1.10
2	Bulbs, electric, tungsten filament, 60 W	.50
20	Burners, bunsen	25.00
12	Burners, alcohol	8.40
1	Caliper, vernier, sliding, wood; demonstration	3.85
2	Calipers, outside, inside	1.70
12	Cans calorimeter, polished	7.20
12	Cans overflow with catch buckets	17.40
1	Capillarity apparatus	1.80
1	Cell, Leclanché	1.00
1 set	Charts, birds, native	2.00
	Carried forward	857.91

Quantity	Item	Total cost in dollars
	Brought forward	857.91
1 set	Charts, birds, migratory	2.00
1 set	Charts, biological, on tripod	45.00
1 set	Charts, human physiology, on tripod	18.00
24	Clamps, boss-head	12.00
24	Clamps, burette	9.60
12	Clamps, condenser, 24 cm	10.80
48	Clamp holders, right angle, small	21.60
12	Clay pipes	1.25
2	Cloud forming, demonstration apparatus	3.35
6	Clips, screw type, tubing	1.80
18	Clips, spring type, tubing	2.24
18	Clips, universal, test	3.60
1 pr	Coils, electrical induction; primary and secondary concentric	6.50
1	Coil, induction; demonstration	13.00
12	Compasses, pocket	9.00
1	Compass, mariners model	8.00
1	Condenser, Liebig, 50 cm	1.50
1	Conductometer, heat, for solids	2.35
1	Convection apparatus, for air	2.75
2 doz	Cover glasses, microscope 18 mm sq	7.00
36	Covers, gas-jar	1.10
12	Crucibles, and lids, porcelain	6.00
1	Cube, decimetre, metal	—
1	Cylinder and piston for Archimedes Principle	2.75
2	Cylinders, graduated, 5 ml	1.80
2	Cylinders, graduated, 10 ml	1.80
3	Cylinders, graduated, 25 ml	3.00
6	Cylinders, graduated, 50 ml	6.60
12	Cylinders, graduated, 100 ml	15.60
12	Cylinders, graduated, 250 ml	27.00
2	Cylinders, graduated, 500 ml	6.00
1	Cylinder, graduated, 1000 ml	4.15
6	Cylinders, wood 4 × 4 cm	4.20
1	Diamond, writing	4.00
1	Disc, Newton's for motor rotor	2.00
1	Disc, siren, for motor rotor	1.70
6	Discs, wood 10 × 2 cm	1.80
10	Dissecting sets	13.50
10	Dissecting trays	12.00
1 doz	Dry cell batteries	6.00
2 prs	Electrodes, platinum	3.50
2	Electro-magnets, lifting, 6 cm	7.50
4	Electrolysis, apparatus, battery jar type	3.00
1	Engine, hot air, model	14.50
1	Engine, steam, model, toy	12.00
1	Engine, model, gasolene, single cylinder	14.75
1	Engine, steam turbine, model, toy	13.00
1	Engine, model, automobile	35.00
1	Engine, model, diesel	30.00
12	Flasks, Pyrex, 125 ml conical	3.60
24	Flasks, Pyrex, 250 ml conical	9.60
24	Flasks, Pyrex, 500 ml conical	13.92
24	Flasks, Pyrex, 500 ml Florence	13.92
3	Flasks, Pyrex, 1000 ml conical	1.92
2	Flasks, Thermos	4.50
1	Foot-candle meter, photoelectric type	24.00
20 prs	Forceps, 15 cm iron	4.00
1 pr	Forceps, blunt, stainless steel	.50
	Carried forward	1,369.46

Quantity	Item	Total cost in dollars
	Brought forward	1,369.46
1 pr	Forceps, sharp, stainless steel	.50
1 pr	Forceps, bone	3.00
4	Forks, tuning C = 256, E = 320, C = 512	6.00
2	Forks, tuning, mounted on resonance box, G384	15.00
1 set	Funnels, filling, glass, small	.75
20	Funnels, filter, 75 mm	13.00
2	Funnels, filter, 100 mm	1.70
1	Funnel, filter, 15 cm	.50
24	Funnels, thistle tubes, Pyrex 20 cm	6.00
1	Galvanometer, galvano-volt-ammeter, demonstration	75.00
1	Gravity apparatus, simple, Duff	6.00
12	Gelatines, floodlight, colored	2.40
24	Glasses, watch, 5 cm	1.92
24	Glasses, watch, Syracuse type	3.50
4	Hall's carriage, for inclined plane	9.00
1	Heater, immersion, electric, 500 W	8.75
1 pr	Hemispheres, Magdeburg, discs	7.50
2	Hydrometers, 0.7-1	2.00
2	Hydrometers 2-1	2.00
1	Hygrometer	7.50
4	Inclined plane boards with pulley	15.00
1	Illuminator, parallel ray	17.50
6	Knives, cork	2.40
1	Lamp, carbon arc, demonstration	7.00
24	Lamp chimneys, Argaud	7.00
24	Lamp chimneys, student	4.80
1	Lamp, Davy, safety	7.50
1	Lantern, projection, 15 cm lens, with micro-projection attachment	182.50
4	Lenses, hand reading glass	4.60
4	Lenses, double concave, 50 mm, f = 20 cm	5.40
4	Lenses, double concave, 50 mm, f = 30 cm	5.70
4	Lenses, double convex, 50 mm, f = 10 cm	3.40
4	Lenses, double convex, 50 mm, f = 20 cm	5.40
4	Lenses, double convex, 50 mm, f = 30 cm	5.70
1	Level, water	1.00
2	Lung demonstration apparatus	7.50
48	Magnets, CoCr, 15 × 0.7 cm, bar	14.40
4	Magnets, 15 × 0,5 cm	4.00
10	Magnets, U form, 14 cm	7.50
20	Magnifiers, tripod, double lens	30.00
100	Maps, weather, blank	—
2	Measures, 1000 cc white enamel	2.00
36	Medicine droppers	1.20
24	Metre sticks, with inches on reverse side	8.40
8	Microscopes, student, two objectives	860.00
144	Microscope slides, glass, blank 7.6 cm × 2.5 cm	2.15
2	Mirrors, concave and convex, demonstration	11.00
24	Mirrors, plane	3.60
1	Model of human ear	26.50
1	Model of human eye	21.50
1	Model of digestive tract	27.00
1	Model of lungs	31.00
1	Model of heart and thorax	30.00
1	Model of skin section	12.50
1	Model of jaw and teeth	17.50
1	Model of kidney	19.50
1	Model of head	27.00
6	Mortars and pestles, 11 cm	11.10
	Carried forward	2,991.73

Quantity	Item	Total cost in dollars
	Brought forward	2,991.73
1	Motor, St. Louis, large demonstration	20.00
1	Motor, electric, disassembled	2.25
1	Model each: paramecium, hydra, frog skeleton, rabbit skeleton	50.00
1	Needle, magnetic, dipping	4.50
24	Needles, dissecting, stainless	1.00
3 pkg	Needles, darning	1.50
36	Needles, knitting, steel	1.20
1	Optical demonstration disc with accessories	57.00
1	Organ pipe; metal with sliding piston, 90 cm	11.00
3	Osmometers, Lyon form with extra membranes	5.25
36	Petri dishes	16.10
6	Pipettes, 1 ml	3.20
6	Pipettes, 25 ml	5.16
6	Pipettes, 50 ml	7.32
24	Pithballs, assorted colours	1.10
1	Planetarium, demonstration	67.50
30	Plates, glass, 71/2 × 71/2 cm	3.60
1	Power supply for low voltage AC and DC current operating from 110 volts AC	25.00
2	Prisms, glass, 60° × 60° × 60°	1.40
2	Prisms, glass, 90° × 45° × 45°	1.40
1	Psychrometer, sling	8.50
24	Pulleys, bakelite, single	10.80
12	Pulleys, bakelite, double	6.60
12	Pulleys, bakelite, treble	8.40
1	Pump, air, pressure and vacuum, motor driven	75.00
1	Pump plate	7.50
1	Pump filter, Cr. plated	2.50
1	Pump, lift, glass model	1.85
1	Pump, force, glass model	1.85
1	Pump, lift, iron commercial pitcher type	3.00
36	Push buttons	7.20
2	Radiometers, Crooke's single set of vanes	10.00
1	Rheostat, sliding 2 A, 41 ohm	13.85
1	Rotator motor driven and accessories	100.00
1	Rotating stand for magnets	2.00
24	Rulers, wood, English and metric scales	5.00
1	Sandglass, 1 minute	.30
12	Scissors	13.00
1	Screw-jack apparatus	12.40
1	Sectioning razor	4.50
1	Siren plate for rotator	1.70
24	Slides, micro, leaf, stem, and root	10.20
24	Spatulas, horn, 125 cm	4.08
18	Stands, filter	22.40
18	Stands, retort	14.40
2 kg	Steel wool	.80
20	Stands, test tube	24.00
18	Stands, tripod with ring, 6 in	18.00
1	Stereoscope	12.00
1	Stop-clock	5.00
1	Syringe, glass	.50
4	Telegraph keys	12.00
4	Telegraph sounders	20.00
2	Telegraph sets, student outfit	11.00
4	Telegraph relays	34.00
4	Telephone receivers	12.00
4	Telephone transmitters	10.00
	Carried forward	3,783.54

Quantity	Item	Total cost in dollars
	Brought forward	3,783.54
4	Telephone induction coils	20.00
2	Telephone sets, student outfit	20.00
10	Thermometers, 32°-220° F × 1° and —10°-110° C	20.00
4	Thermometers, ungraduated	1.35
1	Thermometer, maximum-minimum	10.00
12	Tiles, square, white 10 × 10 cm	4.80
10	Tongs, crucible, 20 cm	3.00
24	Triangles, pipe stem	2.70
10	Troughs, pneumatic, metal	10.00
4	Troughs, mercury, iron	2.00
6 gross	Tubes, test, various sizes	48.00
144	Tubes, test, Pyrex	8.64
24	Tumblers	2.40
1	Voltmeter, triple range 0/1.5/15/150 V	36.50
1 set	Weights commercial	20.00
1 set	Weights, ¼ oz-2 lb	5.60
1 set	Weights, 1 g-1 kg brass	4.50
12	Weights (spare), 0.01-2 g	4.00
1	Wheel and axle, demonstration	2.35
4 sets	Weights, Universal hook; 10-1000 g	27.00
	Total	4,036.38

(*b*) *Tools*

See Tool list for *Physics*

(*c*) *General Supplies*

5 g	Asbestos, platinized	2.20
36	Candles, paraffin	.90
20	Copper strips, 12 × 25 cm	1.50
68 cg	Corks, assorted	7.50
6	Deflagrating spoons, brass	.90
12 pkg	Filter paper	3.60
20 ft	Fuse wire, 5 amp	.40
12	Gauzes, copper, fine mesh, 12 × 12 cm	1.20
24	Gauzes, iron, asbestos centre	4.32
12	Ignition tubes, Pyrex, 15 × 18 cm	2.40
8 bottles	Iron filings, 402, bottle with sifter	2.10
4	Iron strips, 20 × 25 cm	.20
2 boxes	Labels, gummed	.30
1 quire	Paper, emery, assorted	1.75
3 pkg	Paper, sand, assorted	.75
1 roll	Paper, waxed	.50
2 m	Parchment, 50 mm	.75
144	Pins, blanket	1.50
12 paper	Pins, common	1.00
6	Rods, glass friction	3.60
3 kg	Rod, glass 3-7 mm	3.60
6 kg	Stoppers, rubber assorted	13.50
12	Tubes, $CaCl_2$, straight	1.30
1.5 kg	Tubing, capillary, glass	3.80
6 kg	Tubing, glass, assorted, 3-7 mm	9.60
12	Tubes, glass 25 × 450 mm	2.80
30 m	Tubing, rubber, various sizes	18.00
8 m	Tubing, rubber, pressure, 7 mm inside diam	8.75
2	Tubes, silica	.80
288	Tubes, specimen 25 × 50, 70 and 100 mm	10.40
	Carried forward	109.92

Quantity	Item	Total cost in dollars
	Brought forward	109.92
24	T-tubes, glass 4 and 6 mm	4.00
24	U-tubes, glass, 20 × 120 mm and 600 mm	6.10
2000 g	Wire, copper, insulated, bell	1.00
1500 g	Wire, copper, bare No. 30	3.00
1 spod	Wire, NiCr No. 28	2.75
100 g	Wire, phosphor-bronze, No. 30	.40
100 g	Wire, piano, brass	.80
100 g	Wire, piano, steel	.60
	Total	128.57

(*d*) *Chemicals*

250 g	Acetic acid 36 %	.25
250 g	Acetone	.60
2 l	Alcohol, methylated	1.40
250 g	Aluminium foil, thin	.95
250 g	Aluminium sheet 0.5 mm	.85
100 g	Aluminium wire, 1 mm	.45
2 kg	Ammonium hydroxide	2.20
100 g	Ammonium molybdate	1.05
250 g	Ammonium nitrate	.30
100 g	Ammonium oxalate	.40
250 g	Ammonium sulphate	.40
2 kg	Anthracite, coal	.45
250 g	Antimony powder	.60
125 g	Asbestos, mineral, lump	.70
125 g	Asbestos paper	.30
125 g	Asbestos tape, 25 mm	.72
250 g	Asbestos wool	.94
250 g	Barium chloride	.50
500 g	Benzene	.50
500 g	Bleaching powder	.35
100 g	Calcium metal shavings	1.25
3500 g	Calcium chloride	3.60
250 g	Calcium nitrate	.55
100 g	Calcium phosphate, di-acid	.20
250 g	Calcium sulphate, pure	.60
100 g	Camphor	.50
3 kg	Carbon disulphide	2.60
100 g	Carborundum powder, coarse	.35
100 g	Carborundum powder, fine	.35
100 g	Casein, soluble	.60
500 g	Charcoal, animal, granulated	.60
500 g	Chloroform	.75
250 g	Citric acid	.62
25 g	Cloves, oil of	.60
2 kg	Coal, bituminous	.45
1	Coal fossil, specimen	.60
100 g	Cobalt chloride	1.00
500 g	Copper foil	1.10
500 g	Copper, granulated	1.00
500 g	Copper oxide, tech., powder	.88
3 kg	Copper sulphate, crystals	1.90
100 g	Dextrin, pure	.73
500 g	Dextrose	.72
30 g	Eosin solution	.50
500 g	Ether	.90
25 g	Fellis bovini extract	.75
	Carried forward	37.61

Quantity	Item	Total cost in dollars
	Brought forward	37.61
100 g	Ferric phosphate, soluble	.40
30 g	Fluorescein, soluble	.45
2 kg	Formalin	1.60
125 g	Gelatine, sheet	1.08
500 g	Glycerine	1.05
250 g	Graphite lump	.68
7 kg	Hydrochloric acid	4.40
100 g	Iodine crystals	1.75
25 g	Iodoform	.60
3 kg	Iron filings, coarse	2.40
3 kg	Iron filings, fine	2.40
100 g	Iron powder, hydrogen reduced	.45
100 g	Iron wire	.50
250 g	Iron oxide, magnetic lump	.75
500 g	Iron sulphide, sticks	.35
500 g	Lamp black	.60
250 g	Lead foil	.45
500 g	Lead, granulated	1.05
500 g	Lead shot	.75
250 g	Lead wire	.60
500 g	Lead oxide, powder PbO	.75
2 kg	Lignite	.50
100 g	Litmus	1.75
48 vials	Litmus paper, blue	4.80
48 vials	Litmus paper, red	4.80
60 g	Magnesium ribbon	1.20
25 g	Magnesium wire	1.00
500 g	Magnesium carbonate	.60
250 g	Magnesium sulphate	.40
3 kg	Manganese dioxide, powder	2.25
250 g	Mercuric oxide, red	2.75
3 kg	Mercury	24.75
30 g	Methyl violet	.35
25 cc	Methylene blue solution	.45
100 g	Millon's reagent	.90
1 kg	Naphthalene, markless	.55
3 kg	Nitric acid	2.65
1 kg	Paraffin wax	.80
2 kg	Peat	.60
25 g	Pepsin, granulated	.35
25 g	Phenolphthalein, indicator	1.05
250 g	Phosphorus, powder, red	.70
500 g	Phosphorus, yellow	1.90
3 kg	Plaster of Paris	1.75
25 g	Potassium metal	1.85
3 kg	Potassium chlorate	4.95
250 g	Potassium hydroxide, pellets	.65
100 g	Potassium iodide	1.40
500 g	Potassium permanganate	.75
25 g	Potassium thiocyanate	.25
25 g	Pyrogallol	.50
2 sets	Rocks and minerals, students collection of 40 specimens, unlabelled	3.80
1 kg	Rock salt, lump	.45
25 g	Silver nitrate	1.25
500 g	Soap, soft, green	.80
500 g	Soda-lime	.75
250 g	Sodium metal	.65
1 kg	Sodium bicarbonate	1.25
	Carried forward	136.82

Quantity	Item	Total cost in dollars
	Brought forward	136.82
500 g	Sodium carbonate, anhydrons	·75
5 kg	Sodium chloride	1.50
1 kg	Sodium hydroxide, pellets	1.58
500 g	Sodium hypochlorite, solution	.60
500 g	Sodium potassium tartrate	1.50
4 l	Sodium silicate solution	1.30
250 g	Sodium sulphate	.40
500 g	Starch, potato	.85
500 g	Steel filings, coarse	·50
100 g	Sucrose	·50
500 g	Sulphur, native mineral	·50
1 kg	Sulphur, roll	·70
1 kg	Sulphur, sublimed	·70
4 ½ kg	Sulphuric acid 95-98 %	2.25
100 g	Tin foil	·75
100 g	Tin granulated	·75
500 g	Vaseline, yellow	.60
2	Washington School rock and mineral collection in case	14.00
1	Wax stick	·35
500 g	Wool, cotton, absorbent	1.20
100 g	Wool, glass	1.00
500 g	Xylene	·75
250 g	Zinc foil	·75
3 kg	Zinc, mossy	3·30
500 g	Zinc oxide	.85
	Total	174·75

3. MATHEMATICS

There has been some general improvement in the methods of teaching mathematics, although not comparable to that attained in other branches of science. Such an improvement has also resulted from the adequate provision and use of equipment. This point is clearly expressed in the following quotation:

" In a large measure, the success of our courses in mathematics has depended on the degree to which the classroom takes on the physical appearance, spirit and attitude of a well-organized laboratory in which developments of new principles, the assignment, supervised study, recitation, and the testing programme all find their place and are economically interrelated. It is not enough that desirable facilities be provided; they must be arranged so as to present a unified, attractive picture. Providing for mathematics an adequate equipment and a setting that is convenient and appropriate is receiving increasing attention in our schools." [1]

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[1] Op. cit., p. 15.

A. COURSE CONTENT

(*a*) *Arithmetic*

Numbers. The four operations, divisibility, prime numbers, prime factors. Fractions. Decimal numbers, operations. Proportions. Square root. Practical problems, units, measurements.

(*b*) *Geometry*

Plane geometry. Straight lines, vectors, angles, parallelism, perpendicularity. Plane figures, triangles, squares, etc.; polygons, congruence, inequalities. Circle, arcs, tangents, intersection.

Proportionality, proportional and harmonic divisions. Similarity, symmetry of figures. Similar triangles, metric relations. Polygons. Graphical constructions, loci. Definition of higher curves, conics. Areas.

Solid geometry. Plane, lines, angles, parallelism, perpendicularity, symmetry, similarity. Simple solids, cube, prism, pyramid, cylinder, cone, sphere, polyhedrons. Volumes and areas. Application to cosmography, latitude, longitude.

Orthogonal projection, representation. Rudiments of technical drawing.

(*c*) *Trigonometry*

Arcs and angles. Circular functions, general formulae, graphs, numerical tables. Right angle triangles, solution of general triangles, simple trigonometric equations.

(*d*) *Algebra*

Extension of the idea of number. Directed numbers, algebraic operations. Integral, positive, negative, fractional powers. Roots, monomials, polynomials, brackets, factorization, remarkable identities.

Rational fractions.

Vectors, rectangular co-ordinates.

Functions of one variable. Variation, graphical representation.

Equations, first order, one unknown. Inequations. Solution, discussion of results. Problems involving such equations. Simultaneous equations. Quadratic equations, one unknown. Roots, relation between roots and coefficients. Study of the quadratic trinomial, sign, homographic function, graphs. Geometrical meaning of the derivative, tangent. Graphical representation, maximum and minimum.

Uniform motion, constant velocity and constant acceleration motion.

Problems involving quadratic equations.

Exponential function, logarithms, slide rule.

B. SECONDARY SCHOOL EQUIPMENT FOR MATHEMATICS

(*a*) *Individual Equipment*

Quantity	Item	Total cost in dollars
40	Compasses and pencils	8.00
40	Drawing boards	120.00
20	Protractors, bristol board, 35 cm diam	14.00
40	Rulers, wood, 30 cm	8.00
40	Slide rules, student	15.00
40	Slide rule manuals	16.00
	Total	181.00

(*b*) *Classroom Equipment*

1	Blackboard drawing set	6.00
1 pr	Blackboard dividers, 45 cm	3.00
20 pkg	Crayons, coloured	6.00
1	Rule, carpenter's, 2 m	1.25
1	Straight edge, steel, 1.5 m	17.50
4	Triangles, celluloid, 30° × 60° × 45°	4.00
	Total	37.75

(*c*) *Laboratory Equipment*

Quantity	Item	Total cost in dollars
1	Angle mirror	16.00
1	Cone dissectible	12.00
1 set	Geometrical curves, solids and surfaces	6.00
2 sets	Marking pins, steel	12.00
1	Pantograph	11.50
1	Planimeter	12.00
2 sets	Protractors, full circle	60.00
1	Rod, leveling	28.00
2	Rules, parallel	4.50
1	Slide rule for demonstration 1.20 m	10.00
3	Slide rules, various types	70.00
1	Sine demonstration board	15.00
1	Surveying board	20.00
1	Tangent demonstration board	16.50
	Total	293.50

4. PHYSICS

A. Course Content

Subjects	Demonstration and experiments
(*a*) *Mensuration*	
Units of measurement, metric system, English system	Measurement of length, area, volume, weight and time.
Density	Density of a regular and an irregular body.
(*b*) *Mechanics of liquids*	
Liquid pressures are proportional to depth and density	Upward, downward and sidewise pressures are equal. Relation between pressure and depth.
Pressure is independent of shape. Liquids seek their levels	
Pressure applied to liquids, Pascal's Law	Hydraulic press.
Buoyancy, Archimedes' Principle	Submerged bodies. Floating bodies. Archimedes' Principle, sinking bodies, floating bodies.
Specific gravity, solids heavier than water, solids lighter than water, liquids	Loss in weight by displacement of water. Bodies heavier than water. Bottle method and hydrometer. Liquids heavier and lighter than water.

Subjects	Demonstration and experiments
(*c*) *Mechanics of gases*	
Air has weight	Weigh air.
Air exerts pressure	Collapse can by extracting air. Magdeburg hemispheres.
Barometers, mercury, aneroid; weather depends on air pressure	Prepare mercury barometer. Weather maps.
Other applications of air pressure, dirigibles	Balloons, lift pumps, and siphons.
Compressed air, Boyle's Law; applications	Effect of compressing air. Boyle's Law. Force pump, atomizer, caisson. Cartesian diver.
Bernoulli's Principle	Venturi tube, carburettor. Aeroplane wing. Atomizer. Air pressure and Bernoulli's Principle.
(*d*) *Mechanics of solids*	
Properties of matter, stresses of various kinds, elasticity	Tension, compression, bending, twisting and shear. Hooke's Law.
Molecular motion, gases, liquids, solids	Porous cup demonstration. Mixture of NH_3 and HCl. Copper sulphate and water. Camphor.
Molecular forces	Cohesion, adhesion, surface tension, capillary action.
Concurrent forces	Determine resultant.
Composition of forces, resolution of forces	Parallelogram of forces. Resolve weight on inclined plane into components.
Parallel forces, principle of moments, equilibrium	Metre stick set up. Moments in a lever.
Centre of gravity, point where all the weight may be considered concentrated, stability, stable equilibrium, unstable equilibrium	Determine centre of gravity of regular and irregular objects. Cone on base. Billiard ball.
Motion, velocity, acceleration, laws of motion, inertia, momentum, action-reaction	Inclined acceleration board. Bodies fall at same rate. Inertia ball. Horizontally and vertically dropped ball reach ground at same time. Read spring balances.
Centrifugal and centripetal forces	Twirl weight on string, or cup of water, overhead.
Work, power, energy. Work is force × distance, power is the rate at which work is done, horse power, potential, kinetic energy.	Tow a car over table with spring balance. Determine horse power of student running upstairs. Determine horse power of electric motor. Determine potential energy of a raised weight. Determine kinetic energy of falling steel ball.

Subjects	Demonstration and experiments
Machines, lever, pulley, inclined plane, wedge, screw, wheel and axle, gears	Lever set-up (1st, 2nd, 3rd types). Up-pull and down-pull on pulley set-up. Inclined plane. Jackscrew. Wheel and axle, water wheels. Gear chains.
Friction	Bearings, lubricants. Compare towing weights over table and in frictionless car.
(*e*) *Heat*	
Nature of heat, kinetic energy	
Expansion due to heat: solids; liquids, particular expansion of water, thermometers (C and F); gases; Kelvin or Absolute Scale	Expansion of solids, liquids, gases. Unequal expansion. Calibrate thermometer.
Transmission of heat; conduction in solids, liquids and gases; applications. Convection in liquids and gases, applications. Radiation, applications	Heat transmission in metals. Ice in bottom of test tube. Air thermometer in water on which ether burns. Convection currents. Bright and black body radiation. Thermos bottle.
Change of state. Heat units, measuring specific heat, fusion, pressure lowers freezing point, impurities lower freezing point, heat of fusion. Heat absorbed in solution, vaporization and condensation, boiling point varies with pressure, heat of vaporization, evaporation a cooling effect, humidity, relative humidity	Calorimeter demonstration. Specific heat of a metal. Various metals melt paraffin. Paraffin contracts, ice expands. Weighted wire cuts through ice. Freezing point of salt water. Method of mixtures. Cooling curve. Water mixed with salts to demonstrate heat absorption. Boiling under reduced pressure. Evaporation of ether, alcohol, water. Determine humidity. Disappearance of heat during evaporation and solution.
Heat engines	Demonstrate various models.
(*f*) *Sound*	
Origin of sound, sound is caused by a rapidly vibrating body of matter	Cause of sound.
Transmission of sound, sound requires elastic media, sound is transmitted in compressional waves	Absence of sound in vacuum. Type of waves.
Velocity of sound in air	
Reflection of sound, reflecting surfaces produce echoes	
Musical sounds, loudness depends upon amplitude, pitch depends on frequency, quality depends on overtones and fundamental	Demonstrate loudness. Demonstrate pitch. Demonstrate quality, fundamental and overtones in a string forced to vibrate.

Subjects	Demonstration and experiments
Resonance and interference, forced vibrations, sympathetic vibrations, resonance, beats	Tuning fork struck and stem pressed on table. One fork sets another of equal frequency vibrating at a distance. Tuning fork over resonant air column. Frequency of tuning forks by resonance. Mounted tuning forks with adjustable riders.
Musical instruments	Pitch in string instruments.
Musical scale, string instruments, wind instruments	Pitch in wind instruments.
Recordings, phonograph; records	How records may be made.
(*g*) *Light*	
Transmission and measurement, candle power, foot candles	Inverse square law. Measurement of candle power.
Reflection, diffused reflection, regular reflection, law of reflection, images in a mirror, curved mirrors	Demonstrate difference between diffused and regular reflection. Angle of incidence equals angle of reflection. Constructing image in mirror. Convex and concave mirrors.
Refraction, law of refraction, index of refraction, prism, critical angle and total reflection, lenses, converging and diverging image constructions, application	Bending of light rays on entering media of different density. Tracing path of ray of light through rectangular glass prism (or triangular prism). Total reflection. Effect of convex and concave lenses on light rays. Study of images formed by convex and concave lenses.
Colour, dispersion of white light, colour of light depends on wave length, colour of opaque objects depends on selective reflection, colour of transparent objects depends on selective transmission, colour of mixed pigments depends on subtractive process	Pass white light through triangular prism. Exhibit electromagnetic spectrum. Examine coloured pictures under monochromatic light. Pass white light through coloured screens. Mix blue and yellow paints.
Spectroscope	Analyze sodium flame.
Polarized light	Effect of polarized light on samples of transparent materials.
(*h*) *Magnetism*	
Nature of magnetism Magnetic materials, kinds of magnets, polarity, temporary and permanent magnets, magnetic fields, theory of magnetism	Magnetic and non-magnetic substances. Like poles repel, unlike attract. Differences between temporary and permanent magnets. Study magnetic fields. Making a magnet.
Terrestrial magnetism	Earth's magnetic field.
(*i*) *Static electricity*	
Nature of static electricity, electrification of two kinds, conductors and insulators, charging by contact and by induction, electron theory, radio tube, photoelectric tube	Like charges repel, unlike attract. Examples of conductors and insulators. Electroscopes (pith ball and gold leaf). Discharge of electroscope by hot wire. Photo tube and relay.

Subjects	Demonstration and experiments
Effects of static electricity, charges concentrate on points, point discharge, charges reside on outside of conductor, condenser effect, radio condenser, lightning	Use static machine to generate high voltage. Exhibit condensers.
(*j*) *Current electricity*	
Voltaic cells, defects	Zinc-copper-acid cell with galvanometer. Polarization and local action. Voltaic cell.
Dry cell	Zinc, carbon, sal-ammoniac and electric bell. Construction of dry cell. Dry cell cut lengthwise.
Ohm's Law, amperes, volts, ohms, current varies directly as voltage and inversely as the resistance, laws of resistance	Effect of varying length, diameter, temperature and material of wire.
Series and parallel circuits, essential characteristics of each kind of circuit	Demonstrate different circuits. Effect on brightness of lamps when wired in series and parallel.
Effects of the electric current, magnetic effect, magnetic field about current-bearing conductor, electromagnet, right hand rule, strength depends on ampere turns, applications. Chemical effect, electrolysis, storage cell, electroplating	Iron filings on current bearing conductor. Effect on compass needles. Iron core and wire, electromagnet. Electromagnetism and the electric bell. Principle of the electric motor. Electrolysis of water. Demonstrate lead storage cell.
Heating effect, electric current causes heat, applications	Electroplating. In series, heat is greatest in highest resistance; in parallel, greatest in lowest resistance.
Measuring instruments Moving coil galvanometer, ammeter, voltmeter, meaning of fall of potential in an electric circuit, watt-hour meter, cost of electrical energy, units	Exhibit instruments. Suspend fine wire coil between poles of horseshoe magnet. Measure resistance by ammeter-voltmeter method. Fall of potential in series and parallel circuits. Cost of electrical appliances.
Electromagnetic induction, Faraday's Principle, electric generators, Lenz's Law, back EMF in motor, induction coil, transformer, telephone transmitter and receiver	Coil made to cut magnetic field. Faraday's Principle. Demonstrate magnets, student generator. Disconnect electric motor from 110 V circuit and press socket prongs against steel wool. Induce current in secondary of dissectible coil. Induce current in step up and step down transformer. Demonstrate telephone circuit.
Alternating current power, impedance, capacitance	Demonstrate effect of condenser and choke coil in AC circuit.

	Subjects	Demonstration and experiments
(*k*)	*Radiations*	
	Cathode rays, discharge through vacuum	Demonstrate tube discharges.
	X-rays	Exhibit and demonstrate X-ray tube.
	Radio-receiver	Resonance in a radio circuit.
	Radio-activity	Particles emitted by radio-active materials.
	Atomic energy	

B. SECONDARY SCHOLL EQUIPMENT FOR PHYSICS (40 Pupils)

(*a*) *Apparatus*

Quantity	Item	Total cost in dollars
1	Acceleration board, steel ball, and lycopodium	6.00
2	Adhesion disks, 75 mm	1.40
1	Air pump, pressure and vacuum	70.00
9 m	Air pump tubing	5.25
1	Air thermometer, bulb 50 mm, stem 30 cm	7.50
1	Ammeter-Voltmeter AC, demonstration table type 0-3 and 0-15 Amps, 0-15 and 0-150 V	65.00
6	Ammeters, DC 10 A	198.00
1	Ampere's rule apparatus	5.00
1	Archimedes' apparatus, bucket and cylinder	2.75
1	Arc lamp demonstration	7.00
2	Balances, dial, spring, 0-15 kg	10.00
1	Balance, demonstration	3.50
20	Balances, platform, triple beam, capacity 1610 g	360.00
12	Balances spring 0-2000 g, dial face	21.00
12	Balances spring 0-500 g, dial face	21.00
12	Balances spring 0-250 g, dial face	21.00
1	Ball, inertia, iron, 75 mm diam	1.45
3	Balls, iron, 25 mm diam	.75
6	Balls, wood, 50 mm diam	1.20
2	Balls, steel, 20 mm diam	.50
24	Balls, pith, assorted colours	1.10
1	Ball and ring apparatus for expansion	1.75
24	Balloons, rubber	1.30
1	Bar, compound, differential expansion	.60
12	Bars, soft iron, 9.5 × 2 × 0.6 cm	1.60
1	Barometer, aneroid	13.50
1	Barometer, mercurial	27.50
6	Barometer tubes, 90 cm with Hg well	7.50
1	Battery, storage, 6 V, 100 Ah	24.00
1	Battery, storage, demonstration	2.75
1	Beaker copper, 250 ml	1.40
24	Beakers, Pyrex, 250 ml	6.00
24	Beakers, Pyrex, 400 ml	7.44
24	Beakers, Pyrex, 600 ml	9.12
12	Beakers, Pyrex, 1000 ml	8.88
1	Bell in vacuo-jar, 2 l	5.00
1	Bell jar, straight form closed top, 2 l	6.50
1	Bell jar, straight form closed top, 12 l	18.00
1	Bell jar, tall form	13.50
1	Bell jar, swelled form, 2 l	6.50
1	Bell electric for demonstration	25.00
12	Bells, electric, small	10.20
	Carried forward	1,007.44

Quantity	Item	Total cost in dollars
	Brought forward	1,007.44
12	Benches, optical complete with accessories	12.20
1	Block and tackle, with rope	4.00
12	Blocks, waterproofed, wooden, not loaded	6.00
1	Board, wood, friction block	1.50
3	Bombs, ice, cast iron	4.50
12	Bottles, specific gravity, 50 ml	10.80
1	Bow, violin	5.75
1	Boyle's Law apparatus, adjustable tubes	13.50
1	Boyle's Law apparatus, J-tube	11.50
1	Brake-horsepower apparatus	22.50
5	Bridges, Wheatsone, slidewire student type	37.50
2	Brownian movement apparatus	7.50
1	Bulb, atomizer, 50 ml	.50
18	Bunsen burners	22.50
1	Bunsen burner, sensitive flame	3.75
1	Bunsen burner, monochromatic flame attachment	1.25
1	Cage, Faraday's	3.00
6	Calipers, micrometer, 25 mm	35.70
6	Calipers, vernier, 10 cm	30.00
12	Calorimeters, double wall aluminium, stirrer	36.00
2	Camera obscura (pin hole camera)	4.00
1 set	Capillary tubes and reservoir	2.00
1	Case, litre, glass-faced	9.75
12	Catch bickets	7.80
1	Catskin fur for static electricity	3.00
1	Cathode ray deflection tube	16.50
12	Cells, dry, standard	9.00
12	Cells, standard, student with accessories	22.20
1	Centre of gravity set	1.25
1	Centrifugal globe	6.00
1 set	Centrifugal hoops, 20 cm	1.75
1 set	Chladni's plates and holder	4.00
1	Chart of metric and English units	4.75
2 sets	Chart, colour, spectrum	5.00
24	Clamps, burette	9.60
24	Clamps, condenser	18.00
24	Clamps, right angle, large	34.80
24	Clamps, right angle, small	10.80
12	Clamps, right angle, swivel	36.00
24	Clamps tube, screw type	7.20
24	Clamps tube, spring type	4.32
24	Clamps, test tube	2.50
1	Coil, choke with transformer and lamp	28.50
1 set	Coils, primary and secondary, concentric	6.50
1	Coil, induction, box form	15.00
1	Collision ball apparatus	8.50
1 set	Color lantern slides, Wescott's	10.00
18	Commutators, knife switch type	26.00
15	Compasses, magnetic, tracing, 10 mm diam	3.75
15	Compasses, magnetic, pocket type	11.25
2	Compasses, standard base, 15 cm long	1.90
12	Composition of force boards, with balances	54.00
1	Compton, chart of electromagnetic radiations	10.00
14	Condensers, Liebig, 400 mm	18.90
2 pr	Condenser plates	1.30
60	Connectors, wire double, brass	12.00
1	Conductometer, heat, for solids	3.50
2	Constant level tubes, hydrostatic paradox	7.50
1	Convection of gases apparatus	11.50
	Carried forward	1,727.71

Quantity	Item	Total cost in dollars
	Brought forward	1,727.71
1	Convection of liquids apparatus	1.85
2	Copper plating outfits	5.00
1	Conductivity of solutions apparatus	2.00
20 m	Cord, lamp	4.60
3 sets	Cork borers, with handles	10.50
1	Cork borer's hardener	2.15
250 g	Cork dust	.75
8 bags	Corks, Nos. 0-11	6.80
1	Crooke's tube with cross for shadow, 20 cm	15.00
1	Cube, glass, 5 cm edge	2.25
1	Cube, Leslies'	5.50
1	Cup, Tantalus, 15 cm	2.00
12	Cylinders, aluminium, with hook 7.5 × 2.5 cm	6.00
1	Cylinder, friction, Tyndall's	2.00
1	Density apparatus, maximum for water	8.75
2	Density rods graduated, loaded	2.00
1	Dew point apparatus, simple	1.65
1	Diesel engine model 4 cycle and 2 cycle	63.75
1	Differential hoist, ¼ capacity	22.00
1	Diffusion apparatus, for gases	1.65
1 set	Discs, Magdeburg, pressure, 12.5 cm	7.50
1	Disc, Newton's colour	2.50
1	Disc, optical, demonstration with accessories	54.00
1	Disc, siren for rotator, and air jet	7.25
2	Discs, cohesion, glass, 7.5 cm sq	2.00
1	Discharger, Leydon jar	2.00
24	Dishes, crystallizing, 10 × 5 cm	19.40
24	Dishes, evaporating, porcelain, 100 ml	14.88
1	Doppler's principle apparatus for rotator	7.00
1	Double cone and inclined plane	2.45
1	Dynamo, demonstration	38.75
1	Ear, human, model of	26.50
1	Electrical whirl	1.75
6	Electrodes, carbon 6 × 125 mm	4.80
1	Electromagnetic, demonstration apparatus	12.50
2	Electromagnets, interpole distance 4 cm	7.50
12	Electromagnet attachments for St. Louis motor	18.00
1	Electrolysis, apparatus, Hoffman type and support	19.85
1	Electrolytic conductivity apparatus	5.25
1	Electrophorus	9.00
2	Electroscopes, fur use with projection lantern metal case	12.00
2	Electroscopes, pithball	2.80
1	Electroscope, vacuum tube	12.00
1	Ellipsoidal conductor on stand for static electricity	7.75
12 sheets	Emery paper, fine	1.20
1	Engine, automobile, model, manually operated	35.00
1	Engine, model, hot air	14.50
1	Eye, model, dissectable	21.50
2	Faucets, Fuller ball type, cutaway	5.00
2	Faucets, compression type, cutaway	3.00
24	Files, triangular, 6 in	7.20
24 pkg	Filter paper, 11 cm diam	7.92
6 cards	Fish line, 30 lb test	3.60
2	Flamel pads, for static electricity	.60
24	Flasks, Florence, 500 ml, Pyrex	13.92
24	Flasks, Erlenmeyer, 125 ml, Pyrex	7.20
24	Flasks, Erlenmeyer, 250 ml, Pyrex	7.68
24	Flasks, Erlenmeyer, 500 ml, Pyrex	9.60
12	Flasks, Erlenmeyer, 1000 ml, Pyrex	7.68
	Carried forward	2,336.94

Quantity	Item	Total cost in dollars
	Brought forward	2,336.94
4	Flasks, boiling, short neck, 500 ml, Pyrex	3.60
4	Flasks, boiling, short neck, 1000 ml, Pyrex	4.00
3	Flasks, Thermos, 1 l	7.00
1	Fluoroscope, screen	14.75
1	Fluorescent lighting demonstration unit	18.50
2 books	Foil, aluminium for electroscope	2.00
1	Foot-candle meter	24.00
1	Frame, inverse square law	5.00
1	Galvano-volt-ammeter, table, demonstration	88.75
12	Galvanometers, student, portable	162.00
1	Galvanometer, d'Arsonval type	12.50
1	Gas engine model 4 cycle	14.75
1	Gauge, liquid pressure	2.00
24	Gauzes, wire, 16 mesh 4 × 4	1.44
24	Gauzes, wire, asbestos centre 10 × 10 cm	2.88
6	Geissler tubes, 15 cm various shapes	9.00
1	Generator, 6 V, 6 A	22.50
1	Govenor, Watt's, for rotator	7.25
12	Graduated cylinders, 500 ml	36.00
6	Graduated cylinders, 250 ml	13.50
6	Graduated cylinders, 100 ml	7.80
6	Graduated cylinders, 25 ml	6.00
6	Graduated cylinders, 10 ml	5.40
1	Guinea and feather tube	15.50
1	Gyroscope, demonstration	35.00
1	Gyroscope, bicycle wheel type	20.00
12	Hall's carriages, for inclined plane	27.00
1	Hand and bladder glass	9.00
1	Hooke's Law apparatus	2.00
12	Horseshoe cores, soft iron	1.80
1	Hydraulic press, demonstration, model	62.50
1	Hydraulic ram, glass model	6.50
4	Hydrometers, for light liquids	4.00
4	Hydrometers, for heavy liquids	4.00
24	Hydrometer jars	19.20
1	Hydrometer, battery testing	1.60
1	Hygrometer	7.50
1	Hygrodeik	27.00
12	Hypsometers, copper with tripod, complete	73.80
1	Illuminator, parallel ray, 110 V	17.50
12	Inclined planes, 120 × 12.5 cm with pulley	45.00
4	Inclined planes, 5 m long with ball for law of falling bodies	24.00
20 sets	Induction coils, Gilley form	80.00
1	Insulating stool, for static electrical demonstrations	9.75
5 kg	Iron filings, in ½ kg shakers	3.85
1	Jack screw, demonstration	6.00
1	Jar, Leyden, removable coatings	5.00
1	Kilowatt hour dial, demonstration	3.00
1	Lamp board, wired for series and parallel circuits	5.00
18	Lamps, miniature, electric, 1.5 V	3.25
3	Lamps, neon, glow	1.95
12	Lead elements for battery 22 × 125 mm	.70
5 kg	Lead shot, for specific heat	7.15
12	Lenses, double convex, 10 cm focus, 38 mm diam	5.40
12	Lenses, double convex, 20 cm focus, 38 mm diam	4.80
12	Lenses, double concave, 10 cm focus, 38 mm diam	9.20
3	Lenses, reading glass	3.45
1	Lever apparatus, compound form, with weights	6.50
6	Linear expansion apparatus, lever type, complete	51.00
	Carried forward	3,416.46

Quantity	Item	Total cost in dollars
	Brought forward	3,416.46
6	Linear expansion apparatus, micrometer form, complete	30.00
6	Light boxes, double window, with accessories	66.00
1	Liter block, dissectible	5.35
4 pieces	Lode stone, natural magnet	1.20
1	Lung demonstration apparatus	7.50
1	Magnetoelectric generator	12.35
2	Magnets, polished steel, chrome	2.00
6 pr	Magnets, bar, round, CoCr	32.70
6 pr	Magnets, bar, rectangular, alnico	22.20
12 pr	Magnets, bar 15 $\times$ 1.9 $\times$ 0.7 cm	10.80
12	Magnets, breaking	4.20
6 pr	Magnets disc, alnico	11.10
12	Magnets, horseshoe, alnico	8.40
12	Magnets U-shaped	9.00
2 sets	Magnetic screens, para and di-magnetic	1.40
2	Manometers, open tube, demonstration	18.00
1	Manometric flame apparatus, complete for rotator	6.85
100	Maps, weather	.85
1	Maximum density of water apparatus	8.75
1	Measure, litre, white enamel	2.50
4 sets	Measures, liquid, 1 pint to 1 gallon	8.00
4	Mechanical equivalents of heat, tubes	2.00
24	Medicine droppers	.80
18	Metre sticks, graduated in metric and English units	12.60
12	Metre sticks, half metre	4.20
1	Metronome, $^1/_3$ and 1 ½ seconds	11.50
2	Microscopes, student	240.00
24	Mirrors, plane, 4 $\times$ 15 cm	3.60
24	Mirror supports	8.40
1	Mirror, concave for demonstration, 40 cm diam	6.50
1	Mirror, convex for demonstration, 40 cm diam	5.50
1	Mirror, concave and convex, 10 cm diam, frame and handle	2.50
24	Mirrors cylindrical, concave and convex	16.80
1	Molecular vibration tube	2.75
1	Motor St. Louis, large demonstration	19.25
12	Motors, St. Louis, with permanent magnets	75.00
2	Needles, magnetic, dipping	9.00
2	Newton's rings apparatus	6.30
1	Oersted's Law apparatus	11.50
1	Oscillograph, cathode ray	136.50
2	Osmosis apparatus, Lyon form	3.50
3	Pads, silk, 30 $\times$ 30 cm for static electricity	1.95
2 pkg	Paper, blueprint	.70
2 pkg	Paper, coordinate	.40
1	Pascal's vase apparatus	28.75
1	Pendulum and clamp	4.00
1	Photoelectric cell and relay, Weston	21.50
4	Photometers, Bunsen with photometer box, complete	25.00
1	Photometer, Rumford type	9.50
1	Pipe, organ with sliding piston	11.00
1	Pisa, leaning tower, model of	2.25
1	Plate for air pump	29.75
1 set	Plates, glass, coloured, fitters 10 cm^2, 1 each, red, orange, yellow, green, blue, indigo and violet	5.60
4	Platinum wires fused in glass	2.40
12	Plates, glass, refraction 7 $\times$ 7 cm $\times$ 9 mm thick	8.40
1	Polaroïd, experimental set, for optical bench	40.00
1	Polaroïd, demonstration set, for optical disc	12.50
1	Power unit, low voltage	25.00
	Carried forward	4,492.51

Quantity	Item	Total cost in dollars
	Brought forward	4,492.51
1	Pressure apparatus for liquids, glass cylinder with disc complete	5.25
1	Prism, equilateral, 25 × 100 mm mounted	7.50
12	Prisms, equilateral, 7.5 cm face × 9 mm thick	10.20
12	Prisms, 60°, 25 × 100 mm	13.80
12	Prism support blocks	3.60
12	Protractors, brass	2.50
2	Proof planes	1.00
1	Psychrometer, sling	8.50
24	Pulleys, single, bakelite	10.80
24	Pulleys, double, bakelite	16.80
12	Pulleys, triple, bakelite	11.40
50 yds	Pulley cord, fish line, linen	1.20
1	Pulse glass	1.25
2	Pumps, hand, pressure and vacuum	12.00
1	Pump, force, glass model	1.85
1	Pump, lift, glass model	1.85
1	Pump, lift, iron, pitcher type	3.50
1	Pyrometer, demonstration	17.50
2 sets	Quincke's accoustic tubes	6.50
1	Radiation, demonstration set	2.00
1	Radio demonstration panel, receiving	65.00
1	Radio demonstration panel, transmitting	60.00
2	Radiometers	10.00
8	Receptacles, lamp, mounted	2.00
1	Rectifier, dry plate type	11.50
1	Rectifier, tungar, trickle-charger	25.00
2	Reflectors, parabolic	15.00
1	Refraction tank, with protractor	2.25
1	Resistance box, 99.9 ohms	17.50
5 sets	Resistance coils, for Wheatstone bridge	30.00
12	Resonance tubes, accoustical	10.80
12	Rheostats, 90 ohm, slide wire type	174.00
36	Ringstands, with 3 rings, base 10 × 15 cm	81.00
1	Rod, permalloy	12.50
3	Rods, rubber, 25 × 1.3 cm	3.75
24	Rod supports, 40 cm, 13 mm diam for tripod bases	18.00
6	Rod supports, 80 cm × 13 mm diam	6.60
2	Rods, friction, hollowglass, 25 × 1.3 cm	1.00
12	Rods, soft iron, 15 cm × 1.2 cm	2.40
12	Rods, steel, 15 × 1.2 cm	3.10
12	Rods, wood, 1 cm sq × 30 cm long	1.20
1	Rotator, motor driven	85.00
12	Rulers, 30 cm, metric and English scales	.72
1	Safety lamp, Davy's	7.50
1	Second Law of motion apparatus	2.25
1	Short-wave radio demonstration apparatus complete with accessories	54.00
12	Sinkers, lead with hook, 175 g	6.00
1	Siphon, with suction tube	2.25
24	Sockets, miniature electric	2.88
1	Solenoid, with iron core	3.75
3	Sonometers, weight tension type	89.25
2 sets	Specific gravity specimens	6.50
1	Specific heat, demonstration set, Tyndall's	3.75
1	Spectrometer, grating type, with attachments	44.00
1	Spectrum chart	5.00
1	Spectrum tube, argon	4.85
1	Spectrum tube, helium	4.85
	Carried forward	5,506.66

Quantity	Item	Total cost in dollars
	Brought forward	5,506.66
1	Spectrum tube, hydrogen	4.00
1	Spectrum tube, mercury	4.00
1	Spectrum tube, neon	4.85
1	Spectrum tube, oxygen	4.00
1	Speed indicator	5.50
1	Spirometer	22.50
1	Spinthariscope	5.85
1	Spring, spiral brass, 2 m long	2.65
1	Static machine, Wimhurst type	55.00
1	Steam engine, model, toy	12.00
1	Steam engine, model, cutaway	8.75
1	Steam turbine, model, toy	13.00
1	Stroboscope, complete	90.00
6	Supports, swivel, for magnets	2.00
1 set	Surface tension frames	2.25
1 set	Sympathetic vibration plates with resonator	15.00
1	Sympathetic electrical vibration apparatus	18.50
1	Syringe fire, glass with tinder	9.00
4	Switches, single pole, single throw, porcelain	1.20
4	Switches, single pole, double throw, porcelain	2.00
4	Switches, double pole, single throw, porcelain	2.20
4	Switches, double pole, double throw, porcelain	3.20
4	Switches, miniature, porcelain	.80
2	Telegraph keys	6.00
2	Telegraph sounders	10.00
2	Telegraph relays	17.50
2	Telephone induction coils	9.50
2	Telephone receivers	6.00
2	Telephone transmitters	5.00
1	Test board, for volt and ammeter connections	7.25
1 gross	Test tubes, Pyrex, 20 × 150 mm	10.08
12	Test tube brushes	.75
12	Test tube supports, 12 tubes	12.00
1	Thermocouple, lifting magnet	22.50
12	Thermometers C and F, —10° to 110° C, —10° to 220° F	23.00
12	Thermometers, ungraduated	12.00
1	Thermometer, bimetallic	3.00
3	Thermometers, special low temperature	13.50
3	Thermometers, special high temperature	13.50
1	Thermometer, Leslies, differential	8.00
1	Thermometer, maximum-minimum	10.00
1	Thermostat, model, adjustable	4.00
1	Torsion apparatus	58.50
1	Total reflection apparatus, lucite, complete	8.50
1	Transformer, demonstration	16.50
24	Triangles, pipe stem	2.70
18	Tripod bases for 13 mm rods	36.00
4	Troughs, pneumatic	4.60
1 set	Tubes capillary mounted	1.80
12	Tubes, Charles' Law with mercury index	21.00
1	Tube, glass, with iron filings	.65
24	Tubes, thistle, Pyrex	5.28
1 set	Tubes, singing	4.00
1	Tube, Venturi	2.60
1	Tube, X-Ray, 7 cm bulb	25.00
12	Tuning forks C = 256	23.40
12	Tuning forks E = 320	23.40
12	Tuning forks G = 384	23.40
12	Tuning forks A = 426.6	23.40
	Carried forward	6,269.22

Quantity	Item	Total cost in dollars
	Brought forward	6,269.22
12	Tuning forks C = 512	23.40
1	Tuning fork, electrically driven	28.50
1 set	Tuning forks mounted on resonator boxes G = 384	15.00
1	Ultraviolet demonstration set	6.35
1	Vacuum tube testing outfit	12.50
1	Vibrograph, self activating	6.85
6	Voltmeters, DC multiscale 150/7.5 V	216.00
1	Wand, neon	3.35
1	Watch, stop	13.75
24	Watch glasses, crystal type	1.44
24	Watch glasses, Syracuse type	3.50
1	Weight of air cylinder	5.00
12 sets	Weights, metric, hook type, 10-1000 g	90.00
2 sets	Weights, metric, slotted, 10-500 g	11.00
2 sets	Weights, metric, brass, 1-1000 g	22.00
1 set	Weights, English, commercial with rings, 2 1 lb; 2 2 lb; 2 4 lb; 2 10 lb	16.40
1	Wheel, water model	17.50
1	Wheel, Savart's, toothed	5.65
1	Wheel and axle, demonstration	2.35
1	Whistle, Galton's	10.00
24	Wingtops for bunsen burners	3.60
1	Wire testing machine	24.75
	Total	6,808.11

(*b*) *Tools*

5	Auger bits, for carpenters' brace	2.25
12	Blades, hack saw	.80
1	Block, mild, steel	1.15
1	Brace, carpenter's with ratchet	2.50
2	Bradawls	.40
2	Calipers, inside and outside	1.90
2	Chisels, cold	.60
4	Chisels, wood	1.75
1 set	Countersink bits	1.25
1	Dividers, steel, 15 cm	.85
1	Drill, hand, 3-jaw chuck	3.50
1 set	Drills, twist	2.20
10	Files, various sizes and forms with handles	3.50
1	Frame, hacksaw	1.25
2	Gimlets	.30
1	Glasscutter diamond	1.10
1	Gouge, scribing	1.00
1	Grinder and polisher, motor driven	100.00
2	Hammers	1.50
1	Lathe, 10 cm centres	350.00
1	Mallet, joiners	.60
1	Motor, for grinder, polisher, and lathe	50.00
1	Oil can	.80
2	Oilstones, coarse and fine	2.30
1	Plane, jack	5.20
1	Plane, smoothing	2.35
2 pr	Pliers, electricians	4.30
2 pr	Pliers, snub nose	3.60
2 pr	Pliers and nippers	4.00
1	Punch, centre	.50
2	Rasps	.80
1	Rule, carpenter's, folding	.75
	Carried forward	553.00

Quantity	Item	Total cost in dollars
	Brought forward	553.00
1	Rule, steel, metric, in cm retractable	3.50
1	Saw, bow	2.60
1	Saw, panel	2.10
1	Saw, tenon	2.00
1	Saw, hand	6.25
1	Saw, keyhole	2.50
2	Scribers	.30
5	Screwdrivers	3.00
1	Shearing machine	22.00
2 pr	Snips, tinners'	2.40
2	Soldering irons, electric	5.00
1 set	Spanners	2.40
1	Spirit level	1.75
1	Spokeshave	1.60
1	Square, try, steel	.90
2 sets	Stocks and dies	22.00
2	Stone slips for sharpening	.90
1	Vice, parallel, anvil	10.50
1	Vice, woodworker's	6.50
	Total	651.20

(*c*) *General Supplies*

12	Candle holders	2.40
24	Clips, crocodile	7.20
1	Fire blanket, asbestos	32.50
1	Fire extinguisher	14.00
1	First aid cabinet	22.50
100 g	Insulating tape	.40
2 doz	Plates, lantern (for drawing diagrams)	2.50
4	Rods, rubber, 25 × 1.3 cm	1.40
500 g	Solder and solder flux	1.75
12	Sponges, cellulose	6.00
5 kg	Stoppers, rubber, 1 hole assorted sizes	15.00
5 kg	Stoppers, rubber, 2 hole assorted sizes	15.00
5 kg	Stoppers, rubber, solid assorted sizes	15.00
2 kg	Tubing, glass, heavy wall, 3 mm inside diam	6.82
5 kg	Tubing, glass, assorted, 5 and 6 mm	6.60
5 kg	Tubing, glass, assorted, 7 and 8 mm	6.60
3 kg	Tubing, glass, Pyrex, assorted, 6, 7, 8 mm	6.27
30 m	Tubing, rubber, 6 mm inside diam, red, med. wall	5.00
30 m	Tubing, rubber, 8 mm inside diam, red, med. wall	5.60
30 m	Tubing, rubber, 7 mm inside diam, red, heavy wall	16.00
1000 g	Wire, copper, bell, annunciator, insulated	2.50
500 g	Wire, copper, magnet, double cotton covered No. 24	2.50
500 g	Wire, copper, magnet, double cotton covered No. 28	3.00
500 g	Wire, copper, magnet, copper enamel cover No. 30	2.50
500 g	Wire, copper, soft, bare No. 32	3.50
30 g	Wire, fuse lamp	2.00
250 g	Wire, German silver, bare No. 28	2.00
500 g	Wire, iron, No. 28	1.10
1 spool	Wire, nichrome (or chrome) No. 28	2.75
	Total	210.39

(*d*) *Chemicals*

2 l	Alcohol, ethyl, denatured	1.00
500 g	Ammonium chloride	.70
500 g	Ammonium hydroxide	.60
	Carried forward	2.30

Quantity	Item		Total cost in dollars
		Brought forward	2.30
100 g	Camphor balls		.50
500 g	Carbon tetrachloride		.75
1 kg	Copper sulphate, crystals		.70
500 g	Ether, pure		.90
1 kg	Hydrochloric acid		.75
6 kg	Mercury		49.50
1 kg	Naphtalene flakes		.60
500 g	Paraffin, solid		.40
500 g	Sodium chloride, technical		.20
500 g	Sodium chloride, pure		.20
500 g	Sodium, nitrate, pure		.40
500 g	Sodium, thiosulphate, pure		.70
1 kg	Sulfuric acid		1.50
12	Zinc strips, amalgamated, 22 × 125 mm		2.40
		Total	61.80

5. CHEMISTRY

A. COURSE CONTENT

Wherever the expression "the chemistry of" appears, it is meant to include such topics as historical background, occurrence, preparation, physical and chemical properties, and uses or applications of the substance under consideration.

Subjects	Demonstration and experiments
(*a*) *Introduction*	
Preliminary laboratory work Measurement Historical background of chemistry The role of chemistry in modern life	Bunsen burner, manipulating glass, laboratory techniques, measurement.
(*b*) *The chemical nature of matter*	
The physical states of matter	Physical and chemical change.
The identification of matter Physical properties, chemical properties	Mixtures and compounds. Burning, heating metals in air. Oxygen.
The classification of matter, elements, compounds, law of definite proportions, analysis and synthesis; mixtures, solutions as mixtures, air as a mixture	Hydrogen. Reduction by hydrogen. Other sources of hydrogen.

Subjects	Demonstration and experiments
The changes that matter undergoes. Physical change, chemical change, types and simple word equations, factors that induce and regulate chemical change	Electrolysis of water (demonstration). Conservation of matter.
Two key elements in chemistry: oxygen — the chemistry of oxygen, burning, spontaneous combustion, dust explosions; Lavoisier's work; hydrogen — the chemistry of hydrogen, hydrogenation; oxidation and reduction; the composition of water, analysis by electrolysis, synthesis by reduction of cupric oxide, synthesis in a eudiometer, law of combining volumes; hydrogen peroxide and the law of multiple proportions	
(*c*) *The structure of matter*	
The molecular theory of matter: evidence for molecules, nature of molecules, gas laws and the behaviour of gases	Molecular weight of oxygen, per cent of oxygen in $KClO_3$. Combining weight and valence of magnesium.
The atomic theory of matter: evidence for atoms, the nature of atoms, atomic weights, gram-molecular weights and gram-molecular volumes	
The composition of atoms: review of researches into atomic composition, electrical discharges through gases, radioactivity, X-rays and Moseley's work on atomic numbers, sub-atomic particles: electrons, protons, neutrons, others	
The structure of atoms: orbits and electrons, the nucleus, use of atomic weights and atomic numbers in "diagramming" atoms	
Applications of atomic structure: Outer-orbit electrons and chemical activity, valence, ionic valence and covalence, isotopes, crystal structure and ionic space lattices, oxidation-reduction reactions	
Nucleonics: explanation of radioactivity, transmutation of the elements, nuclear fission and "atomic" energy; electronics, brief introduction	
(*d*) *Solutions and colloids*	
True solutions: nature of; preparation of solutions of desired concentration—percentage composition of solutions, molar solutions, factors affecting solubility; effect of solutes on freezing and boiling points of solvent	Solutions and suspensions.

Subjects	Demonstration and experiments
Separating solutions into solute and solvent—distillation, fractional distillation; crystallization	Crystals and crystallization. Determination of water of crystallization. Distillation.
Near-solutions or colloids—nature of matter in colloidal stage of subdivision; types of colloidal dispersions and their preparation; properties of matter in colloidal condition; applications of colloids	Fractional distillation. Colloids.
(*e*) *Ions in solution; electrolytes*	
Background of theory of ions in solution—lowering of freezing points; conductivity of solutions; Arrhenius' theory; speed of reactions between dry and dissolved electrolytes	Properties of acids and bases. Preparation of acids and bases. Neutralization. Conductivity (demonstration). Double displacement reactions. Hydrolysis.
Reactions explained by ionic behaviour—equilibrium reactions and equations; end reactions and equations; mass action	Electroplating and refining of copper. Per cent of acetic acid in vinegar.
Electrolysis of solutions: ionic explanation of electrolysis: water, HCl, electroplating; chemical cells; storage battery. Acids and bases explained by ionic behaviour—acids and the hydronium ion; bases and the hydroxyl ion; strengths of acids and bases—pH values, normal solutions; neutralization reactions and equations; hydrolysis reactions and equations	Per cent of ammonia in household ammonia water. The chemical cell. The storage battery. Preparation of salts. Calculated yield and experimental yield. Titration; normal solutions.
Electrolytes: general characteristics of acids and bases; general methods of preparing acids, bases and salts—equations; nomenclature of acids, bases and salts	
(*f*) *The halogens as a chemical family*	
The periodic table and the classification of the elements	Chlorine. Hydrogen chloride and hydrochloric acid.
Chlorine as a member of the halogen family—chemistry of chlorine; hydrogen chloride and hydrochloric acid	Bromine. Iodine.
Other members of the halogen family—chemistry of the halogens; family relationships among the halogens; bleaching	
(*g*) *The nitrogen family*	
Nitrogen—chemistry of nitrogen; nitrogen fixation; other gases composing the atmosphere	Composition of air. Ammonia.
Important nitrogen compounds: ammonia—chemistry of ammonia,	Oxides of nitrogen.

Subjects	Demonstration and experiments
refrigeration; nitric acid, explosives; other nitrogen compounds: nitrious acid, oxides of nitrogen	
Other members of the nitrogen family: phosphorus—chemistry of phosphorus, acids of phosphorus; arsenic; antimony; bismuth	Phosphorus and its compounds.
The nitrogen family as related to soils and fertilizers—the nature of soil; maintaining soil fertility—acidity of soil, fertilizers, nitrogen cycle; insecticides	
(*h*) *Sulphur*	
The chemistry of sulphur, the element	Sulphur.
The oxides of sulphur	Sulphur dioxide.
The acids of sulphur—sulphites and their uses; sulphates and their uses; alums	Sulphuric acid.
The sulphides—sulphides as ores of metals; carbon disulphide; hydrogen disulphide	Hydrogen sulphide.
(*i*) *Some base-forming elements*	
The sodium family—chemistry of sodium; chemistry of potassium; important compounds: sodium hydroxide, sodium carbonate, Solvay process	Baking powders.
Calcium and magnesium—natural occurrence; caves and caverns; lime products and their applications; the chemistry of hard water and water softeners	Compounds of calcium. Hard water.
Minerals: silicates; silicate industries—cement, glass, ceramics	
(*j*) *Metals and metallurgy*	
Principles of metallurgy: concentration of the ore; smelting, electrolytic separation; activity series of the metals; refining the metal	Recovery of metals from ores. Activity series of the metals.
Iron and its varieties: chemistry of making pig iron; chemistry of making steel; heat treatment of steel	Oxidation and reduction of iron ores. The thermit reaction (demonstration).
Copper	Alloys and amalgams (demonstration).
Aluminium and magnesium— alumino-thermics	
Other common metals	
Some uncommon metals	
Alloys: nature of alloys; alloy steels; non-ferrous alloys	
Protection and preservation of metals—ionic-electronic explanation of corrosion; methods of protection	

Subjects	Demonstration and experiments
(*k*) *Carbon and organic chemistry*	
Chemistry of carbon, the element	Carbon.
The oxides of carbon	Destructive distillation.
Relationship of carbon to fuels and flames: fuels as energy sources, calorific values of fuels; petroleum and its future—gasoline manufacture, other petroleum products; natural and manufactured gases	Carbon dioxide. Organic acids, alcohols and esters.
Hydrocarbons: homologous series; chains and rings; saturated and unsaturated compounds; substitution and addition products; structural formulae in organic chemistry	Soap making. Carbohydrates. Fermentation; alcohols. Methane and acetylene. Molecular models of organic molecules (demonstration).
Important classes of hydrocarbon derivatives: alcohols, aldehydes and ketones; esters; organic acids; soap making	
Plastics and synthetics—rubber, a natural plastic; synthetic rubber; plastics	
Carbohydrates: sugars, starches, cellulose and its uses	
Food and nutrition—classes of foods; vitamins; alkaloids	
Natural and manufactured fibres and textiles	
Drugs and medicinals	
(*l*) *Applied or consumer chemistry*	
Qualitative analysis: identification of the salts of important acids; analysis for Group I of the metals	Analysis of baking powder. Identification of anions. Borax bead and cobalt nitrate tests.
Household chemistry—fire and burning; fire prevention; fire extinguishers; silverware polishes; cleansing agents	Flame tests. Analysis for Group I metals. Proteins and fats. Identification of textile fibres.
Consumer chemistry—meanings of labels on bottles and packages; comparison of consumer products: vinegar, antifreezes, baking powders	Dyeing. Removal of spots and stains. Paints. Photography.
Dyes, stains, textiles	
Paints, varnishes, lacquers	
Cosmetics	

B. SECONDARY SCHOOL EQUIPMENT FOR CHEMISTRY (36 pupils)

(*a*) *General Desk Equipment and Demonstration Apparatus*

This equipment is usually kept in a separate drawer which is available for use by all classes; it is usually not issued to individual working units. The quantities indicated are based on 12 working units (individual students or groups of 2 or 3 students) and one unit for the instructor's desk. In addition, a reasonable allowance is included for breakage and replacements during the year.

Quantity	Item	Total cost in dollars
36	Alcohol lamps	25.20
12	Aspirator pumps, metal	30.00
6	Balances, triple beam, 111 g. capacity	108.00
1	Barometer, mercury	27.50
16	Blow pipes	8.00
48	Bottles, narrow mouth, mushroom stopper	14.00
12	Bottles, reagent, NH_4OH	6.00
12	Bottles, reagent, HCl, conc	6.00
12	Bottles, reagent, HCl, dil	6.00
12	Bottles, reagent, HNO_3, conc	6.00
12	Bottles, reagent, HNO_3, dil	6.00
12	Bottles, reagent, NaOH	6.00
12	Bottles, reagent, H_2SO_4, conc	6.00
2	Brownian movement apparatus	7.50
18	Brushes, test tube	1.10
18	Bunsen burners	22.50
2	Cells, conductivity	2.00
1	Chart, electrochemical series	2.00
1	Chart of metals	2.75
1	Chart of periodic arrangement of elements, showing atomic structure	7.50
36	Clamps, burette	21.60
24	Clamps, condenser	21.60
30	Clamp holders, right angle	13.50
36	Clamps, Mohr's	6.48
24	Clamps, test tube	2.88
12	Combustion boats, Coors porcelain, 7.6 × 1.1 cm	6.50
3	Desiccators	13.90
18	Files, triangular	3.60
18	Gauze, wire, asbestos centre 7.5 × 7.5 cm	2.70
18	Jars, hydrometer, 30 × 5 cm	14.20
18	Mats, asbestos 15 × 15 cm	3.00
18	Mortars and pestles	19.62
12	Pneumatic troughs, 25 × 17 × 10 cm, galvanized iron	12.00
2	Pneumatic troughs, glass, 30 × 22.5 × 20 cm	17.00
18	Racks, test tube, metal	23.30
18	Spoons, deflagrating, brass	2.70
18	Supports for ring stand, with 3 rings	30.50
18	Tongs, crucible, brass	6.30
18	Triangles, pipe stem, 5 cm	2.10
24	Tubes, ignition, Pyrex, 200 × 25 mm	7.92
4	Water baths, Cu, 12.5 cm diam with rings	9.00
18	Wingtops for bunsen burners	2.70
	Total	543.15

(*b*) *Individual Locker Apparatus*

This list should allow sufficient materials for 12 working units, and if each unit is composed of 2 or 3 students, the materials will be sufficient for a class of 24 or 36 students. The school need only multiply this listing by the number of classes and it will be assured of having correct materials. Students generally keep this apparatus in locker drawers and are often charged for breakage and replacements. Estimated quantities of these materials needed for replacement are included in section (*c*) of this listing.

12	Beakers, Pyrex, 100 ml	3.24
12	Beakers, Pyrex, 250 ml	3.00
12	Beakers, Pyrex, 400 ml	3.72
12	Crucibles, porcelain No. 0	3.60
12	Crucible covers, porcelain No. 0	2.61
12	Cylinders, graduated, 25 ml	10.80
	Carried forward	26.97

Quantity	Item	Total cost in dollars
	Brought forward	26.97
12	Dishes, evaporating, porcelain No. 00A	8.64
12 pkg	Filter paper, 11 cm, diam	3.10
12	Flasks, Erlenmeyer, Pyrex, 250 ml	3.84
12	Flasks, Florence FB, Pyrex, 250 ml	4.80
12	Funnels, 65 mm, short stem, Pyrex	6.60
12	Funnels, thistle tube, Pyrex	2.64
12 vials	Litmus paper, blue	1.20
12 vials	Litmus paper, red	1.20
48	Plates, glass, 8 × 8 cm	2.40
12	Sponges, cellulose	2.40
12	Watch glasses	.96
12	Watch glasses, Syracuse type	1.75
	Total	66.50

(*c*) *General Supplies and Reserve Equipment*

This equipment is usually kept in a general supply room and is issued on loan or for breakage replacement by the teacher or a laboratory assistant. Items from section (*b*) above which are duplicated in this list are for the purpose of providing a reserve supply of individual apparatus to cover breakages.

Quantity	Item	Total cost in dollars
1	Alpha ray track apparatus Knipp	35.00
1	Atomic chart, nuclear transmutation	5.00
1	Atomic model kit	35.00
24	Beakers, Pyrex, 100 ml	6.48
24	Beakers, Pyrex, 250 ml	6.00
24	Beakers, Pyrex, 400 ml	7.44
12	Beakers, Pyrex, 1000 ml	8.88
1	Blast lamp, bunsen form	9.50
60	Bottles, wide mouth	5.25
4 sets	Borers cork, with handles	14.00
12	Burettes, 50 cc with stop cocks, acid	43.20
12	Burettes, 50 cc no stop cock, alkalae	19.20
2	Burners, high temperature	19.00
24	Candles	.60
1	Chart, organic chemistry	7.50
24	Clamps, burette	14.40
24	Clamps, condenser	14.40
30	Clamp holders, right angle	6.48
1 set	Coloured crystal models	10.00
12	Condensers, Liebig, 400 mm	17.20
1	Conductivity tester	5.25
6 pkg	Corks, assorted	5.10
1 set	Crystals, natural large	18.50
12	Crucibles, porcelain	3.60
12	Crucible covers, porcelain	2.61
12	Cylinders, graduated, 25 ml	10.80
6	Cylinders, graduated, 100 ml	7.20
3	Cylinders, graduated, 250 ml	4.95
2	Cylinders, graduated, 500 ml	5.00
1	Diffusion of gases apparatus	1.85
12	Dishes, evaporating, porcelain	8.64
12	Dishes, lead, 75 mm	5.00
1	Distillating apparatus for water	10.00
1	Electroplating outfit	20.00
1	Electrolysis apparatus, Hoffman, mounted	19.20
6	Equivalent weight apparatus	11.10
2	Eudiometer tubes, Ure's, U-shaped, platinum electrodes	6.05
1	Fluorescent minerals kit	6.00
1	Fluorescent liquids set	2.65
	Carried forward	438.03

Quantity	Item	Total cost in dollars
	Brought forward	438.03
24 pkg	Filter paper, 11 cm diam	7.92
1	Fire blanket, asbestos	32.50
1	Fire extinguisher	14.00
1	First aid kit, large, in cabinet	22.50
24	Flasks, Erlenmeyer, Pyrex, 125 ml	7.20
24	Flasks, Erlenmeyer, Pyrex, 250 ml	7.68
24	Flasks, Erlenmeyer, Pyrex, 500 ml	9.60
6	Flasks, filtering, Pyrex, 250 ml	6.00
24	Flasks, Florence, Pyrex, FB, 250 ml	9.60
24	Flasks, Florence, Pyrex, FB, 500 ml	13.92
12	Flasks, Erlenmeyer, Pyrex, 1000 ml	7.68
3	Flasks, filtering, heavy wall, Pyrex, 250 ml	9.15
12	Flasks, Florence, Pyrex, FB, 1000 ml	8.88
6	Flasks, boiling, Pyrex, 1000 ml	6.00
6	Flasks, boiling, Pyrex, 500 ml	5.40
6	Flasks, boiling, Pyrex, 250 ml	4.20
12	Forceps, steel, straight, 12.5 cm	2.40
2	Funnels, separatory, stoppered, 500 ml	7.28
2	Funnels, enamel ware, 6 in	1.20
24	Funnels, glass, 65 mm, short stem	13.20
24	Funnels, thistle tubes, Pyrex	5.28
6	Glasses, test, tall conical, 125 ml	6.60
1	Geiger counter	49.50
1	Gram-molecular volume cube	4.50
1	Hot plate electric	15.00
6 rolls	Hydrion pH test paper and dispensers	9.00
1	Hydrogen ion apparatus, complete	50.00
1	Hydroponics outfit, chemical garden	15.00
50 vials	Litmus paper, blue	5.00
50 vials	Litmus paper, red	5.00
12	Magnifiers, tripod	18.00
2	Microscopes, student	240.00
2	Mortars and pestles, 160 mm	10.34
1	Ozone apparatus, with induction coil	25.00
12	Pipettes, transfer, 10 cc	8.16
12	Pipettes, transfer, 25 cc	10.32
24	Plates, glass, cobalt blue, 5 × 5 cm	2.64
12	Platinum wires, fused in glass	6.00
1 set	Radioactive ore samples	3.00
12	Retorts, Pyrex, glass stoppered, 250 cc	26.46
2 kg	Rod, glass, 6 mm	2.75
1	Soil testing kit	11.00
1	Spectrometer	38.75
1 set	Spectrum tubes, Argon — Helium — Hydrogen — Mercury — Neon — Nitrogen — Oxygen	31.50
1	Spectrum chart	5.00
1	Spinthariscope	5.85
12	Spoons, horn spatula end, 150 mm	3.84
12 vials	Starch, potassium iodide test paper	1.20
3 kg	Stoppers, rubber, 1 hole, various sizes	9.00
4 kg	Stoppers, rubber, 2 hole, various sizes	12.00
3 kg	Stoppers, rubber, solid, various sizes	9.00
12	Thermometers, —10° to 110° C	18.00
12	Tripods, with rings, 20 cm	26.40
18	Tubes, calcium chloride, tall form, 150 mm	5.04
18	Tubes, calcium chloride, U-shaped, 150 mm	12.60
36	Tubes, ignition, Pyrex, 200 × 25 mm	11.88
24	Tubes, test with base and lip, 200 m	9.60
288	Tubes, test, Pyrex, 150 × 18 mm	17.28
	Carried forward	1,379.83

Quantity	Item	Total cost in dollars
	Brought forward	1,379.83
288	Tubes, test, ordinary glass, 150 × 18 mm	8.00
2	Tubing expanders	2.00
1 kg	Tubing, glass, 4 mm	2.50
2.5 kg	Tubing, glass, 6 mm	3.70
2 kg	Tubing, glass, 8 mm	3.00
30 m	Tubing, rubber, 5 mm	22.50
20 m	Tubing, rubber, 10 mm	13.20
3 m	Tubing, rubber, thick walled for high vacuum, 6 mm	3.50
1	Ultraviolet demonstration outfit	6.35
1 set	Valence blocks	1.00
24	Watch glasses, 75 mm	1.92
24	Watch glasses, Syracuse type	3.50
500 g	Wire, copper, No. 30	3.00
500 g	Wire, copper, No. 32	3.00
250 g	Wire, copper, No. 34	3.00
50 g	Wire, nichrome, No. 30	1.65
5 pkg	Wood splints	1.90
4 sq m	Zinc metal sheets, 0.8 mm	1.50
	Total	1,465.05

(*d*) *Chemicals*

Based on 12 working units of 1, 2, or 3 students each, for one year.

250 g	Acid, acetic, 36 %	.25
100 g	Acid, acetic, glacial	.35
100 g	Acid, citric	.35
100 g	Acid, formic, 90 % pure	.60
6 kg	Acid, hydrochloric	3.75
100 g	Acid, hydrofluoric	.75
3 kg	Acid, nitric	2.65
100 g	Acid, oxalic, cryst	.55
100 g	Acid, salicylic	.30
4.5 kg	Acid, sulphuric	2.25
100 g	Acid, tannic	.45
100 g	Acid, tartaric	.65
100 g	Alcohol, amyl	.30
5 l	Alcohol, ethyl, denatured	2.25
0.5 l	Alcohol, methyl	.35
100 g	Alizarine	.55
30 g	Alpha naphthol	.40
500 g	Alum, ammonium (Aluminum Ammonium sulphate)	.30
500 g	Aluminum foil	1.85
500 g	Aluminum sheet	1.75
500 g	Aluminum potassium sulphate	.75
500 g	Aluminum sulphate	.35
500 g	Ammonium carbonate	.65
500 g	Ammonium chloride	.70
250 g	Ammonium dichromate	1.02
250 g	Ammonium ferric citrate (green)	.68
2 kg	Ammonium hydroxide	2.20
100 g	Ammonium molybdate	1.05
100 g	Ammonium nitrate, cryst	.20
100 g	Ammonium oxalate	.55
100 g	Ammonium sulphate	.15
500 g	Ammonium sulphate, dark	.45
1 kg	Ammonium sulphide, solution, CP, light	1.50
100 g	Antimony, lump	.40
100 g	Antimony, chloride	1.10
100 g	Arsenic trioxide	.30
	Carried forward	32.70

Quantity	Item	Total cost in dollars
	Brought forward	32.70
500 g	Barium chloride, cryst	.92
100 g	Barium hydroxide	.80
100 g	Barium nitrate	.50
100 g	Bismuth, metal	1.56
500 g	Bleaching powder	.35
500 g	Bone black	.60
500 g	Borax, pure	.30
500 g	Boric acid	.45
100 g	Brass, sheet	.30
500 g	Bromine CP	1.65
100 g	Cadmium chloride	1.10
500 g	Cadmium nitrate	3.30
500 g	Calcium, metal, turnings	6.00
2.5 kg	Calcium carbonate, marble chips	1.70
500 g	Calcium carbonate, pptd chalk	.45
500 g	Calcium carbide	.35
500 g	Calcium chloride, granulated, pure	.65
500 g	Calcium fluoride	.30
1 kg	Calcium hydroxide	.70
100 g	Calcium nitrate	.30
1 kg	Calcium oxide	.45
100 g	Calcium phosphate, mono, pure	.20
500 g	Calcium sulphate, Plaster of Paris	.30
30 g	Camphor, gum	.20
2 kg	Carbon disulphide	1.95
2 kg	Carbon tetrachloride	2.55
100 g	Casein powder	.45
12	Charcoal blocks	.85
500 g	Charcoal, wood, powd	.40
500 g	Chloroform	.75
100 g	Chromium, sulphate	.68
100 g	Cobalt nitrate, cryst	1.00
30 g	Congo red	.30
200 g	Copper bromide	1.50
100 g	Copper foil, thin	.35
1000 sq cm	Copper gauze	2.12
1000 sq cm	Copper sheet, 0.5 mm	1.20
500 g	Copper turnings	1.00
3 lb	Copper, wire, various diameters	9.00
100 g	Copper chloride, cryst, pure	.65
100 g	Copper nitrate, cryst, pure	.50
100 g	Copper oxide, powd, tech	.40
100 g	Copper oxide, wire form	.25
2 kg	Copper sulphate, cryst	1.25
500 g	Cotton, absorbent	1.50
1 l	Cotton seed oil	.60
100 g	Dextrin	.73
1 kg	Di-sodium phosphate, tech cryst	1.25
30 g	Eosine	.50
30 g	Fluorescein	.45
1 kg	Formalin	.50
30 g	Fuchsine red, acid, powd	.42
30 g	Gallein, red powd	.60
7	Gases bottled, lecture bottles one each, CO_2, Cl_2, H_2, H_2S, N_2, O_2, SO_2	56.00
100 g	Gelatine, gran	.52
100 g	Glucose	.40
500 g	Gypsum	.40
100 g	Hydroquinone	.46
	Carried forward	147.61

Quantity	Item	Total cost in dollars
	Brought forward	147.61
500 g	Hydrogen peroxide	.30
500 g	Iodine, resublimed	5.00
500 g	Iron filings, coarse	.40
500 g	Iron filings, fine, clean	.40
100 g	Iron chloride, ferric	.45
100 g	Iron oxide, ferric, powd	.45
500 g	Iron powder, hydrogen reduced	2.00
500 g	Iron sulphate	1.10
500 g	Iron sulphide, ore, lumps	.50
500 g	Lead foil	.95
1000 g	Lead shot, 3 mm	1.45
500 g	Lead acetate	.80
500 g	Lead nitrate	.65
100 g	Lead oxide (litharge)	.30
100 g	Lithium nitrate, pure	1.10
100 g	Logwood chips	.30
100 g	Magnesium powd	1.00
30 g	Magnesium ribbon	.60
500 g	Magnesium sulphate	.80
30 g	Malachite, green	.50
100 g	Manganese chloride	.60
1 kg	Manganese dioxide	.90
100 g	Manganese sulphate	.50
30 g	Mercuric nitrate	.65
250 g	Mercuric oxide, red	2.75
30 g	Mercurous nitrate	.68
2 kg	Mercury	16.50
30 g	Methyl orange, dry	.60
30 g	Methyl violet	.35
100 g	Nickel chloride, pure	.70
120 g	Nichrome wire, 0.7 mm	1.60
500 g	Paraffin	.40
1 l	Petroleum oil	.75
30 g	Phenolphtalein	1.38
100 g	Phosphorus, red	.45
100 g	Phosphorus, yellow	.60
500 g	Photographic developer	1.10
50 g	Potassium, metallic	3.60
100 g	Potassium acid tartrate	.25
500 g	Potassium bromide	.90
500 g	Potassium chlorate, cryst	.85
100 g	Potassium chloride	.30
100 g	Potassium chromate	.45
100 g	Potassium and chromium sulphate (chrome alum)	.30
500 g	Potassium dichromate	.60
500 g	Potassium ferricyanide	1.80
100 g	Potassium ferrocyanide	.70
1 kg	Potassium hydroxide, pellets	2.25
100 g	Potassium iodide	1.40
500 g	Potassium nitrate, cryst	.60
100 g	Potassium permanganate	.25
1 kg	Potassium and sodium tartrate (Rochelle salt)	.72
100 g	Potassium sulphate	.45
100 g	Potassium sulphocyanate, pure	.75
30 g	Pyrogallol, cryst	.50
100 g	Rose metal	1.35
250 g	Silver nitrate	8.55
250 g	Sodium metal	.65
250 g	Sodium acetate	.55
	Carried forward	224.94

Quantity	Item	Total cost in dollars
	Brought forward	224.94
100 g	Sodium aluminum sulphate (sodium alum)	.30
500 g	Sodium ammonium hydrogen phosphate	.80
100 g	Sodium benzoate	.30
100 g	Sodium bicarbonate	.10
250 g	Sodium bisulphite	.20
125 g	Sodium bromide	.30
500 g	Sodium carbonate, cryst	.68
500 g	Sodium carbonate, pure, dry	.75
2.5 kg	Sodium chloride, salt, fine	.75
100 g	Sodium chromate, powd	.62
1 kg	Sodium hydroxide, pellets	1.58
100 g	Sodium iodide	1.80
500 g	Sodium nitrate	.40
250 g	Sodium nitrite	.30
250 g	Sodium peroxide, powd	.60
100 g	Sodium phosphate (monosodium)	.45
100 g	Sodium phosphate, dibasic	.85
500 g	Sodium phosphate, tribasic	.30
4 l	Sodium silicate, sol	1.30
500 g	Sodium sulphate, cryst	.90
500 g	Sodium sulphite, pure, dry	.42
500 g	Sodium tetraborate (borax)	.30
500 g	Sodium thiosulphate (hypo)	.70
500 g	Starch, corn	.40
500 g	Starch, potato	.85
500 g	Strontium chloride	1.30
30 g	Strontium nitrate	.35
500 g	Sulphur, flowers	.45
500 g	Sulphur, roll	.45
250 g	Tin, granulated	1.75
250 g	Tin, foil, thick	2.00
250 g	Tin, stick	1.20
100 g	Tin oxide	.40
500 g	Wood's metal	4.07
500 g	Wool, glass, fine	.60
1 kg	Wool, steel	.60
100 g	Zinc dust	.38
250 g	Zinc, gran	.75
2 kg	Zinc, mossy	2.20
250 g	Zinc, sheet	.45
100 g	Zinc nitrate	.62
500 g	Zinc sulphate	.42
	Total	258.88

6. BIOLOGY

A. Course Content

(a) Introduction

Use and care of the microscope. Collection and preservation of local plants and animals.

(b) The changing environment

The atmosphere. Preparation of oxygen, hydrogen, nitrogen and carbon dioxide. Water. Effects of moisture on seedlings. Temperature. Effects on sprouting seeds and bacteria colonies. Light. Influence upon growing plants. Soils. Different types of soils. Plants and animals. Simple plant and animal cells.

(c) The adaptations of organisms

Thallus plants. Algae. Yeasts, moulds, and bacteria. Bryophytes and Pteridophytes. Mosses and ferns. Seed Plants. Stems, leaves, roots and flowers: monocots vs dicots.

Invertebrates—

Protozoa, hydra, planaria, earthworm, crayfish and insect.

Vertebrates—

Fish, frog, reptiles, birds and mammals.

Special adaptations: phototropism, geotropism, maze experiment, special senses.

(d) Nutrition

Animal metabolism
  Food tests
  Digestion of foods
  Digestive systems
  Circulatory and respiratory systems
  Oxidation; release of heat energy.
Plant metabolism
  Circulation in plants
  Streaming of protoplasm in Elodea or geranium
  Photosynthesis
  Capillarity
  Osmosis.

(e) Reproduction and heredity

The nature of reproduction. Pollen and grafting. Eggs of earthworm, crayfish, frog, etc. Development of chick embryo.

Reproduction in plants. Growing root tip. Spores of mushroom, mould, ferns, etc. Conjugation of Spirogyra.

Structure and functions of flowers and seeds.

Reproduction in animals: division of Amoeba and Paramecium.

Variation—Mendel's Law; hybrid corn; drosophila crossing.

(f) Biological production

(g) Biological control

Balance of nature
  Saving the soil
  Soil tests
  Study of legumes
  Soil capillarity, porosity, tenacity, water run-off
  Weed control
  Control of insect and rodent pests
  Control of disease.

B. SECONDARY SCHOOL EQUIPMENT FOR BIOLOGY (40 pupils)

(a) *Apparatus*

Quantity	Item	Total cost in dollars
2	Asbestos mats, 22 cm diam	.30
2	Aquaria, 30 l, clear glass	23.00
2	Aquarium heaters and thermostats	15.00
4	Balloons, toy with valve	.20
4	Balances, triple beam, capacity 1610 g	72.00
16	Bath sponges	4.80
120	Beakers, 600 ml, Pyrex	48.00
2	Bell jars	25.00
4	Bell jars, open top	26.00
2	Boards, insect drying	7.50
48	Bottles, wide mouth	5.00
6	Boxes, microscope slide, wood	9.00
5	Burners, Bunsen	5.75
1	Cage, insect 30 × 30 × 45 cm, screen sides	12.00
6	Cages, animal, 37 1/2 × 22½ cm, sloped face and with drawer	49.50
2	Cages, animal, collapsible, 30 × 50 × 37 cm	25.50
6	Cages, animal, jar with screen top 30 × 22,5 cm	34.50
12	Cans, soil sample, 500 ml	1.80
2	Cases, botanical collection, 12 × 17 × 38 cm	—
60	Charts, 30 plants, 30 animals, mounted on tripod	45.00
30	Charts, animal life history	27.50
12	Charts, bacteria of communicable disease, mounted on tripod	70.00
30	Charts, physiology	37.50
1	Chemical garden set, complete	12.00
12	Chimneys, Argaud lamp	2.75
6	Clamps, burette, 15 cm	2.60
1	Cooker, pressure, 10 l	22.50
4 sets	Cork borers	4.00
2 bags	Corks, assorted	3.00
4 lb	Cotton, absorbent	5.40
48	Culture tubes	9.60
24	Dishes, Petri, 10 × 1,5 cm	12.00
20	Dishes, crystallization, 10 × 5 cm	17.00
24	Dishes, evaporating, porcelain, 90 mm	16.28
20	Dishes, Stender, preparation	6.00
6	Dishes, staining, low form	3.90
20	Dissecting sets, student, in cases	35.00
20	Dissecting trays, wax-lined	26.00
1	Evaporimeter, soil, 5 × 12.5 cm	4.20
2 pr	Field glasses	12.00
1 pr	Forceps, bone	3.00
6	Files, triangular, 15 cm	1.80
24	Flasks, conical, 250 cc, Pyrex	7.68
24	Funnels, Pyrex, 75 mm	15.60
6	Gauze, wire, 10 × 10 cm	.90
2	Glass cutters	1.20
48	Glass plates, 8 × 8 cm	2.00
24	Glass stirring rods	2.40
24	Glass tumblers	2.40
6	Graduates, cylindrical, 100 ml	13.50
2	Hot plates, electrical	21.00
2	Incubators, small electric	70.00
2	Innoculating needles with wire	5.25
24	Insect killing bottles, cyanide	7.20
	Carried forward	893.01

Quantity	Item	Total cost in dollars
	Brought forward	893.01
24	Jars, 1 l, screw lids	6.20
24	Jars, preserving, 2 l, with lids	13.40
10	Jars, battery, 5 l, clear glass	15.00
12	Jars, staining	7.20
10	Lamps, substage microscope	40.00
12	Lenses, hand, 6 cm diam	15.00
4 pkg	Lens paper	3.00
10 vials	Litmus paper, red and blue	1.00
144	Medicine droppers	4.80
1	Microscope, stereoscopic, paired objectives 10X and paired eye pieces 10X	181.00
10	Microscopes, student	1,070.00
1	Microtome, hand	30.00
1	Model, anatomical, human brain and skull	19.50
1	Model, anatomical, human ear	26.50
1	Model, anatomical, human eye	21.50
1	Model, anatomical, human heart	19.00
1	Model, anatomical, human torso	157.50
1 set	Models, mitosis	30.00
1	Model, inheritance, monohybrid	3.00
1	Model, inheritance, dihybrid pea	9.00
1	Model of root tip	25.50
1	Model of stem cross section, dicotyledon	25.50
1	Model of stem cross section, monocotyledon	25.50
60	Mounts, Riker's, various sizes	25.00
4	Mortars with pestles	4.50
4 pkg	Needles, dissecting	.80
1	Nest, ant observation, 3 chambers	6.00
5	Nets, insect collecting	10.00
1	Net, ooze collecting	5.35
2	Osmometers, Lyon's form with extra membranes	3.50
10 books	Paper, lens	1.50
20 pkg	Pins, insect, assorted	14.00
1	Photosynthesis, apparatus, simple	3.20
12	Plates, germinating	4.90
2	Platinum wires, glass fused	1.00
15	Pneumatic troughs	15.00
12	Pots, flower, 10 cm	.80
12	Pots, flower, 15 cm	2.50
1	Projector, for micro-work with substage condenser	225.00
2	Racks, test tube, double deck, 24 tubes	2.50
4 boxes	Rubber bands, assorted	3.00
2 sq m	Rubber dam	3.75
15	Rulers, metric-English scales	1.50
12 sheets	Sandpaper, various grades	.60
4	Scalpels, assorted	4.00
3 pr	Scissors, dissecting, various shapes	4.50
1 set	Seed plants, demonstration set, 50 types	12.50
1 set	Seeds, albino corn	1.40
20	Slides, micro, sections of stem, root and leaf	12.00
12	Slides, hanging drop micro	9.00
30	Slides, micro: cross-section Hydra, Planaria, Earthworm—10 each	18.00
10	Slides, micro: whole mounts of protozoa	8.00
1	Slide, micro, showing lily ovule	1.20
2	Slides, micro, showing conjugation and fission (Paramecia and Amoeka)	2.40
1	Soil, auger, for samples	6.00
2 sets	Spoons, measuring	.50
	Carried forward	3,056.01

Quantity	Item	Total cost in dollars
	Brought forward	3,056.01
2	Sterilizers, Arnold's	15.00
6	Supports, iron with 3 rings	13.50
1	Soil testing set, complete	6.50
1	Syringe, laboratory injection with needles	7.00
1	Syringe, hypodermic, Luer's	4.00
2 rolls	Tape, gummed	.50
24	Test tube brushes	1.50
3	Terraria, rectangular, glass, 5 l	21.00
6	Thermometers, Cand F	9.00
24	Thistle tubes	5.30
6	Tripods, 15 cm	6.00
144	Tubes. test, Pyrex, 12 cm	8.64
4	Tubes, capillary, mounted	3.20
6	Tubes, soil, capillary 60 × 5 cm	8.20
144	Vials, shell type, 75 × 15 mm	1.95
96	Watch glasses, Syracuse type	14.00
4	Wax pencils	.72
2	Weights, set of in block 10-500 g	7.50
6	Y-Tube ¼ in	1.20
	Total	3,190.72

(*b*) *Tools*

1	Chisel, cold	1.20
6	Chisels, grafting, 30 cm	15.00
1	Chisel, wood	1.25
1	Drill, breast, with bits	5.50
3	Files, flat	2.75
6	Knives, grafting	1.25
1 pr	Pliers, side cutting	2.00
1	Rasp, wood	1.00
5	Razors, sectioning	15.00
1	Saw, hand	6.25
1	Saw, hack, 3 blades	1.75
1	Screw driver	.70
1 pr	Tin spins	2.75
1	Vice, bench, 15 cm	6.75
	Total	63.15

(*c*) *General Supplies*

12	Candles; spermaceti	4.80
50 g	Cover glass, micro 18 mm diam	9.00
20	Grasses, common	9.20
500 g	Raffia	.72
	Rubber stoppers, assorted sizes and holed	—
300	Slides, micro, 7.5 × 2.5 cm plain	3.00
5 kg	Tubing, glass 7 mm	6.50
15 m	Tubing, rubber 5 mm	7.00
20	Weeds, common	9.00
	Total	49.22

(*d*) *Chemicals and Culture Media*

500 g	Acid, acetic, glacial	.90
3 kg	Acid, hydrochloric	1.35
1 kg	Acid, nitric	1.00
150 g	Acid, picric	.55
4.5 kg	Acid, sulphuric	2.25
	Carried forward	6.05

Quantity	Item	Total cost in dollars
	Brought forward	6.05
500 g	Agar-Agar	2.00
3 kg	Ammonium hydroxide	3.30
250 g	Benedict's solution	.70
2.5 kg	Balsam, Canada	3.00
100 g	Beef extract	1.25
500 g	Calcium carbonate, precipitate	.45
1 kg	Calcium phosphate, dibasic	.75
1 kg	Calcium phosphate, monobasic	.65
1 kg	Calcium sulphate, plaster of Paris	.50
250 g	Carbolic acid, phenol cryst	.50
2.5 kg	Carbon tetrachloride	2.20
1 kg	Charcoal, lump	.80
500 g	Dextrose, anhydrous	.72
500 g	Diastase, malt	2.25
30 g	Eosin, water soluble	.50
1 kg	Ether	1.75
1 kg	Fehling's solution A and B	2.40
1 kg	Ferric chloride	1.10
2.5 kg	Formalin 10 %	1.25
30 g	Gentian violet, dry	.65
100 g	Iodine crystals, resublimed	1.75
1 kg	Lime water	.90
500 g	Lysol	1.00
30 g	Magenta, red	1.25
1 kg	Magnesium sulphate	1.40
1 kg	Manganese dioxide	.90
20 g	Malachite, green	1.05
30 g	Methylene, blue	.90
250 g	Pancreatin	1.50
1 kg	Paraffin	.80
½ kg	Pepsin	5.00
100 g	Peptone	1.50
100 g	Phosphorus, yellow	.60
250 g	Potassium bichromate	.40
2 kg	Potassium chlorate, powd	3.30
100 g	Potassium iodide	1.40
1 kg	Potassium nitrate	1.10
5 kg	Sodium chloride	1.50
1 kg	Sodium carbonate	.60
500 g	Starch, corn	.40
1 kg	Wax, grafting	1.50
2.5 kg	Xylene	2.75
1 kg	Zinc, mossy	1.10
	Total	65.37

PART THREE

VOCATIONAL SCHOOLS

1. INTRODUCTION

The aim of "vocational education" is to provide a broad but preliminary scientific and technical training which is essential for the formation of skilled workers capable of operating modern industry and commerce. During the past few decades it has greatly expanded and supplements very effectively the older system of apprenticeship which is "vocational training".

Vocational education does not aim at any premature specialization and is therefore neither a substitute for proper apprenticeship nor for adequate workshop practice. It constitutes a first stage in technical education corresponding to and attaining the level of a junior high school in the usual educational scheme. Vocational schools enrol pupils with suitable aptitudes after they have completed the primary cycle of education at about 13 years of age. The duration of study is generally four years, and the teaching aims at giving the pupils a wide grasp of the simple principles of science and technology underlying the current occupational practices. These schools train young people for useful employment in agriculture, home economics, trades, industry and distributive occupations in such a way as to protect their future vocational adaptability.

The development of vocational education is considered a vital necessity in modern society and in all the industrially advanced countries an important department in the ministries of education is devoted to it. It is a part of the general economic policy, is well integrated with the structure and trend of production and employment in industry and agriculture and is so organized as to meet the varied regional requirements. Vocational schools are generally attached to corresponding senior technical schools which train specialists for agriculture or for important industries. This link creates a realistic atmosphere in the vocational school and is conducive to a substantial economy in equipments as well as to efficiency in the training of pupils. The latter have access to the agricultural or industrial laboratories and workshops designed for the senior students and the instructors can speak with first-hand knowledge of industrial processes in addition to being aware of the various requirements for skilled manpower.

Since the provisions for vocational education are closely related to the particular requirements of a country, it is rather difficult to select features that can be considered as universally valid. There are as many types of vocational schools in a given region as there are distinct groups of agricultural, industrial or commercial activities. However, there are two broad groups, the industrial and the commercial schools, the former being generally reserved for boys. The following time-tables are given as representative samples of the two categories at present established in France.

Table of hours per week

Industrial Schools

	Preparatory Year	1st Year	2nd Year	3rd Year
Ethics and civics	1	1	1	
Industrial economics, labour legislation				1
French (mother tongue)	6	4	4	3
History	1	1	1	1
Geography	1	1	1	1
TOTAL: Arts courses	9	7	7	6
Arithmetic, algebra, geometry	5	4	4	2
Mechanics				2
General science	2			
Physics and chemistry		2	2	2
TOTAL: Science courses	7	6	6	6

	Preparatory Year	1st Year	2nd Year	3rd Year
Languages	2			
Hand writing and technical drawing	1	4	4	4
Commerce and book-keeping				1
Industrial design	3	2	2	2
Initiation into professional work	6			
Workshop practice, technology		17	20	21
TOTAL: Technical courses	12	23	26	28
Grand TOTAL	28	36	39	40
Physical culture	2	4	4	4

Table of hours per week

Commercial Schools
(For 4th Year Course *see* next Table)

	Accounting			Stenography and typewriting		
	1st Year	2nd Year	3rd Year	1st Year	2nd Year	3rd Year
Ethics and French (mother tongue)	5	5	4	5	5	4
History	1	1	1	1	1	1
Geography	1	1	1	1	1	1
Economics			1			1
TOTAL: Arts courses	7	7	7	7	7	7
Mathematics	3	3	3	3	3	3
Physics	1	1		1	1	
Chemistry and merchandise		1	2		1	2
Zoology, botany	1			1		
Hygiene						1
TOTAL: Science courses	5	5	6	5	5	6
Foreign languages	4	4	4	4	4	4
Commerce, accounting	4	4	6	4	2	3
Correspondence		1	1		1	1
Civil law		2			2	
Commercial law			2			2
Sales			1			1
Handwriting and drawing	2	2	1	2	1	1
Stenography, typing	3	2	2	3	5	6
TOTAL: Professional courses	9	11	13	9	11	14
Practical domestic science	3	3	3	3	3	3
Grand TOTAL	28	30	33	28	30	34
Physical culture	4	4	4	4	4	4

Table of hours per week

Commercial Schools
(4th Year)

	Commercial Clerks	Secretaries	Accountants	Salesmen
Ethics and French (mother tongue)	3	3	3	3
Commercial geography		1		
Economics	1	1	1	1
TOTAL: Arts courses	4	5	4	4

	Commercial Clerks	Secretaries	Accountants	Salesmen
Foreign languages	2	4		4
Commercial and social law; fiscal laws	3	3	3	3
Correspondence and reports	1	2	1	1
Accounting	3		5	
Practical work; office requisites and fittings	1	4	3	
Organization	1	2	1	2
Publicity	1	1		6
Goods	1			3
Stenography, typing, mecanography	5	8	2	2
Applied art drawing, handwriting	1	1	1	2
TOTAL: Professional courses	17	21	16	19
Practical domestic science	3	3	3	3
Grand TOTAL	28	33	27	31
Physical culture	3	3	3	3

The science courses usually cover practical mathematics, physics and chemistry, and may be grouped together in a general science course. Vocational schools are the simplest type of specialized schools and therefore this characteristic is evident even in the general preparatory courses. Some of the conventional chapters are further developed, others are dealt with more rapidly according to their importance in the chosen practical field.

Audio-visual aids have been found most helpful in training skilled workers. A great variety of films, film strips and projection slides are being produced for professional training. The following equipment would be a valuable acquisition to any vocational school by enabling it to take advantage of this type of instruction material:

Visual Aid Equipment

Quantity	Item	Total cost in dollars
1	Motion picture unit, 16 mm	200.00
1	Projector, film strip	65.00
1	Projector, lantern slide	74.00
1	Screen	12.00
	Total	351.00

2. GENERAL SCIENCE

A. COURSE CONTENT

The aim of such a course should not be "to impart necessary information and standard techniques, but to establish the important place of scientific method and knowledge in everyday affairs".

First Year: The world around us

Atmosphere—Composition, burning, water vapour, pressure, barometers, respiration, CO_2 cycle, etc.

Water—Water cycle, solubility, natural waters, pumps, maximum density, pond life; thirst and water in the body, etc.

Earth—Simple geology, soils, nitrogen cycle, ores, some simple extractions, etc.

Second Year: Science in industry and human affairs

In this year a number of problems which have faced mankind are dealt with, and the contribution of science to their solution is shown. The problems should be chosen from all branches of science and the number covered in excess of a certain minimum depend upon the ability of the class. Topical examples: Nitrogen famine and fertilizers, water softening, water purification, steel production, accurate measurement, lighting, good acoustics, ventilation, gas supply, and so on. Allowances would thus be made for local or vocational preferences.

Third Year: The scientist's viewpoint

1. The physicist's viewpoint—Molecular theory and its consequences, simple kinetic theory and atomic structure. On the practical side, surface tension, viscosity, and frictional electricity provide examples.
2. The chemist's viewpoint—The nature of matter, chemical changes, chemical families, the periodic system. On the practical side: elementary qualitative analysis.
3. The biologist's viewpoint—This would provide opportunity for a description of the functioning of the human body.

With pupils entering this course at the age of 13 from schools in which many of them will have had experience of "activity methods", there would be ample opportunity for trying out and finding "activity treatments" which would lead to the more formal second and third year work. At least half the time available should be devoted to independent work, either in the form of experiments or study. The lack of suitable textbooks for such a course would present many difficulties, but a good and easily accessible science library, not part of the general school library, should be built up. Working with the reference books in this library should be included as an integral part of the curriculum.

B. EQUIPMENT.

The same equipment as needed for the secondary school general science course (page 25), the quantities being proportioned to the number of students.

3. MATHEMATICS

A. COURSE CONTENT

(a) Arithmetic

Numbers. The four operations. Divisibility. Mental calculations.

Fractions, operations. Decimal fractions.

Proportions, direct and inverse variation. The rule of three.

Percentage. Simple interest.
Square roots. Tables.
Units of measurement, practical units, angles, arcs.
Longitude, latitude. Measurement of time.
Uniform motion.
Practical problems, elements of commercial mathematics.

(*b*) *Algebra*

Use of letters, signs, monomials, polynomials, algebraic operations, fractions.
First degree equations, one or two unknowns; problems.
Second degree equations. Study of elementary functions.
Graphical representation, practical applications.
Progressions, arithmetical and geometrical.
Decimal logarithms. Tables.
Trigonometric tables.
Slide rule. Practical problems.

(*c*) *Geometry*

Straight line, plane. Measurement of length. Instruments.
Angles. Measurement of angles. Instruments.
Triangles, applications.
Parallel lines and applications. Symmetry.
Circle, properties.
Applications to technical drawing.
Loci.
Similarity. Metrical relations. Polygons.
Conical sections, elementary properties, construction.
Areas.
Elementary trigonometry. Definition of circular functions, fundamental relations, right angled triangle relations. Tables.
Solid geometry. Planes, lines, solid angles, polyhedrons. Sphere, cone cylinder. Areas and volumes.
Practical problems.
Application to technical drawing.

B. EQUIPMENT

The simple equipment needed for this course is listed with that needed for Technical Drawing, see page 77.

4. PHYSICS

These courses, given in the second and third years, while making their contribution to the pupil's general scientific knowledge would be primarily *vocational* in aim. As a pupil's progress in quantitative science is often retarded, not by his inability to understand the new relationship, but by his incapacity to handle its mathematics, there should be a careful integration with the mathematics course. This would give the mathematical processes a strong practical foundation and allow time for the specialized courses.

A. COURSE CONTENT

Generally special stress is laid on physics in vocational schools for metal and woodwork. The physics courses give a connected account of the properties of matter: statics, dynamics, heat, magnetism, electricity, with less emphasis on light and sound. The following subjects are dealt with:

(*a*) *Mechanics*

Units and measurement. Motion, trajectories, velocity, acceleration. Statics, forces, equilibrium, vectors, triangle and polygon of forces, simple frame structures, parallel forces, centre of gravity, weight, specific weight, moments. Dynamics, inertia, fundamental principles, equations of motion, tractive effort, torque, transmission by shafts, belting or gearing work, potential and kinetic energy, centrifugal and centripetal forces. Resistance, friction, lubricants, ball-bearings.

Simple machines: inclined plane, lever, pulleys, screw, edge. Ideal and real machines; efficiency.

Compound machines: pulley blocks, tackle, crane, bicycle, etc. Weighing-machines, transmission of motion, belting, friction wheels, gearing-drive, rack and pinion, bolt and nut, screw threads, crank and rod, cams, etc. Time measurement, clocks.

(*b*) *Motors*

Hand or animal power.

Hydraulic machines, Francis and Pelton turbines. Hydraulic pumps.

Steam generators and engines. Theoretical and practical study. Turbines. Internal combustion engines, spark ignition, compression-ignition.

(*c*) *Strength of materials*

Strength and elastic moduli, limits, elongation, hardness, resilience, deformation, stress and strain, bending moment, shearing forces.

(*d*) *Hydrostatics*

Pressure, Archimedes' principe, density, hydraulic press. Gases, atmospheric pressure, barometer, manometers, Boyle's law, vacuum pumps.

(*e*) *Heat*

Temperature, thermometers, expansion. Nature of heat, conservation of energy and the mechanical equivalent of heat, calorimetry, specific heat, latent heat, calorific value of fuels. Fusion, solidification, vaporization, saturated and unsaturated vapours, evaporation, boiling, condensation. Use of steam tables, heat transfer.

(*f*) *Sound*

Production, propagation and velocity.

(*g*) *Light*

Propagation, reflection and refraction, mirrors, prisms, lenses. Simple optical instruments.

(*h*) *Electricity and magnetism*

Electric current, circuits, chemical effects, electrolysis, electroplating, intensity, potential difference, work and power, meters. Heating effects, Joule's law. Resistance, Ohm's law, cells, electromotive force. Accumulators.

Magnetic fields, natural and artificial magnets, laws of attraction and repulsion, laws of force. Induced magnets, magnetic field of an electric current, electromagnets, bells, relays, telegraphy. Interaction between currents and magnets. Electromagnetic induction. Faraday's and Lenz's laws. Dynamo motors.

Alternating currents, properties as compared with those of direct currents. Intensity, tension, power, work, power factor, phase. Self-induction, capacity, coils, condensers. Alternators, transformers, rotating fields, motors.

Telephony, high frequency currents, units and measurements.

B. VOCATIONAL SCHOOL EQUIPMENT FOR PHYSICS

Quantity	Item	Total cost in dollars
20	Accumulators, Ferronickel, 1.5 V, 50 Ah	60.00
1	Alcoholometer	2.00
1	Altimeter (aneroid)	20.00
4	Ammeters, moving coil, 5 A	40.00
6	Ammeters, moving iron, 40 A	40.00
2	Ammeters, thermic, 10 A	15.00
1	Atwood's machine	50.00
1	Audio oscillator	110.00
1	Balance, general and hydrostatic with weights	65.00
1	Balance, precision, 50 g	90.00
1	Balance, for demonstration	12.00
1	Balance, Roberval, 5 kg with 2 sets of weights	20.00
1	Balance, Roman, 10 kg	4.00
1	Ball and ring apparatus	2.00
1	Barometer, aneroid	9.00
1	Barometer, mercurial, Fortin type	27.50
1	Barograph	140.00
1	Baroscope	15.00
2	Bars, steel, vibrating	12.00
1	Battery, accumulator, 120 V	65.00
4	Bells, electric	3.60
1	Bench, optical, with all accessories	75.00
1	Block and tackle, with rope, double	7.00
1	Boyles law apparatus, adjustable tube type	13.50
6	Bottles, specific gravity 50 cc	5.40
1	Brake-horse power water motor, with pressure gauge	52.50
1	Brake-horse power apparatus for small electric motors, with balances to 15 kg	33.50
1	Brake Prony for measuring horse power	10.50
2	Bridges, Wheatstone, industrial	120.00
1	Cage, Faraday's	6.00
2	Calipers, micrometer	6.00
1	Caliper, vernier, demonstration, 50 cm	4.00
2	Calipers, vernier	5.00
1	Calorimeter, Berthelot's	5.00
1	Camera, lucida	60.00
1	Camera, photographic, with tripod	60.00
1	Cartesian, diver	1.15
1	Cell, Daniell	4.50
1	Cell, standard, cadmium, student type	16.00
3	Cells, demonstration and student	10.00
1	Coil, induction, 25 mm spark	11.00
1	Coil, induction, demonstration type	6.50
2	Coils, self-induction, variable magnetic core	10.00
4	Condensers, electrical	6.20
1	Condenser, electrical, standard, 0.5 μF	57.50
1	Converter, AC/DC, 3.5 kW	60.00
2	Cylinders, Archimedes' demonstration	5.50
1	Differential hoist, ½ ton capacity	30.00
1	Disc, Newton's	4.45
1	Disc, optical, demonstration for geometrical optics, with accessories	37.00
3	Dynamos, shunt, series, and compound excitation	180.00
1	Electromagnet, interpolar distance 4 cm	4.00
1	Electrostatic, demonstration set	36.00
1	Engine and boiler, steam, toy	12.00
1	Engine, steam turbine, toy	13.00
1	Engine, Diesel, model, 2 and 4 stroke	63.75
	Carried forward	1,834.05

Quantity	Item	Total cost in dollars
	Brought forward	1,834.05
1	Engine, hot air	14.50
1	Engine, automobile, model, manual	35.00
1	Engine, gas, model section four cycle, single cylinder	14.75
1	Engine, steam, model, section	8.75
2	Force tables, for vertical and horizontal position, complete	55.00
1	Galvanometer, table type	16.00
1	Grating, diffraction, 586 lines, replica	24.00
1	Gyroscope, bicycle wheel, demonstration type	20.00
1 set	Hemispheres, Magdeburg	12.00
5	Hydrometers, assorted	10.00
1	Hygrometer, wet and dry bulb	6.50
1	Hysteresis, switch	25.00
1	Indicator, Watt's dynamometric	10.00
1	Igenhouz's apparatus (heat conductivity of solids)	4.50
2	Jars, Leyden	9.00
1	Lamp, Davy's	8.00
1 set	Lenses, demonstration, convergent and divergent	10.50
1	Lens, achromatic	5.00
1	Level	3.50
2	Linear expansion apparatus, lever type with various metal bars	20.00
2 sets	Magnets, bar	3.60
1	Manometer, Bourdon's	11.50
2 kg	Mercury	66.00
1	Meter, universal, test	60.00
1	Meyer's apparatus (vapour densities)	4.00
2	Microammeters, portable	60.00
1	Microscope, 2 objectives	150.00
3	Milliammeters, portable, aperiodic	84.00
2	Millivoltmeters	40.00
3	Mirrors, plane, 10 × 10 cm	.30
1	Mirror, revolving for rotator	22.00
1	Motor, experimental ring type, complete	19.25
4	Motors, asyn. 3 kW	144.00
1	Motor, repulsion, monophase, 1 kW	62.00
1	Motor, rotator and accessories	105.00
1	Motor, synchronous 0.5 kW, 3- phase	62.00
4	Needles, magnetic	8.00
1	Oersted's apparatus	11.50
2	Ohmmeters	14.50
1	Oscillograph, cathode ray, 5 in screen	136.00
1	Pascal's vase apparatus	28.75
1	Pendulum, compound	17.50
1	Permeammeter, with galvanometer	200.00
2	Phasemeters, 110 V, 5 A, 50 cycles/second	70.00
1	Photometer, Bunsen's	11.50
1	Plane, inclined, demonstration	10.00
1	Press, hydraulic, for demonstration	62.50
1	Prism, equilateral, mounted	12.00
1	Prism, total reflection	13.50
1	Prism, hollow	16.50
1	Psychrometer, sling	8.50
1	Pump, hand, for vacuum and pressure	6.00
1	Pump, motor, for vacuum and pressure	70.00
1	Pump, plate and accessories	12.50
1	Pump, lift, iron, pitcher type	3.00
1	Pump, lift, model glass	1.85
1	Pump, forces, model glass	1.85
6	Pulleys, bakelite, single	2.70
	Carried forward	3,758.35

Quantity	Item	Total cost in dollars
	Brought forward	3,758.35
4	Pulleys, bakelite, double	2.20
2	Pulleys, bakelite, triple	1.40
1	Pyrometer, demonstration	17.50
1	Radio, short wave apparatus, and wave meter complete	50.00
1	Radio, receiving demonstration panel	65.00
1	Radio, transmitting demonstration panel	60.00
2	Receivers, telephone	6.00
2	Rectifiers, Tungar	60.00
4	Resistance boxes, 99.9 ohms, dial type	70.00
1	Resistance box	10.00
1	Sextant, demonstration	5.00
1	Signal generator, R.F. output	105.00
1	Spectroscope	110.00
1 set	Spectroscopic tubes argon, neon, helium, hydrogen, oxygen	22.00
1	Spherometer	11.50
1	Stroboscope, complete	115.00
2	Switches, starting	52.50
1	Tachometer	15.00
2	Telegraph keys	6.00
2	Telegraph sounders	10.00
2	Telegraph relays	30.00
2	Telephone induction coils	9.50
2	Telephone transmitters	5.00
1	Telescope, terrestrial	15.00
4	Thermometers, double scale C and F	8.80
1	Timer, interval	35.00
2	Torricellian tubes	2.40
1	Transformer, demonstration	40.00
2	Transformers, intensity, 10 to 600 VA	84.00
2	Transformers, 3000/110 and 5500/110 V	110.00
3	Transformers, various ranges 1 to 20 kVA	82.50
1	Triode, demonstration, three elements electron tube	75.00
1 set	Tubes, capillary, mounted	1.80
1	Tube, Newton's	6.00
1	Turbine, steam, demonstration, model	16.00
1	Vapour pressure apparatus	32.50
1	Voltmeter, AC multiscale, 150/15	40.50
1	Voltmeter, DC multiscale, 150/15/1.5	35.00
4	Wattmeters, different ranges	250.00
1 set	Weights, precision, 100 g	32.50
1 set	Weigts, up to 2 kg in block	7.50
1 set	Weights, universal, hook	7.50
1	Wimshurst, static electrical machine	97.50
	Total	5,576.45

5. CHEMISTRY

A. Course Content

This course should give a grounding in elementary chemistry developed to include some important technical processes and to give a fuller understanding of engineering materials. Some of the fundamental facts are already studied in the general science course. The following subjects are treated:

Physical and chemical phenomena, simple and compound substances. The atmosphere, water, oxygen, hydrogen, nitrogen, carbon, coal, CO_3Ca, CO, CO_2. Some non-metals and their common compounds, S, SO_2, H_2SO_4, Cl_2, $NaCl$, HCl, NH_3, HNO_3, P. Si. Acids, bases, salts, molecules, atoms, reactions.

Iron and steel, alloys, properties, simple analysis, ore smelting.

Other common metals, Cu, Zn, Pb, Al, Sn, Ni, Hg.

Elements of organic chemistry. Hydrocarbons, acetylene.

Fuels, industrial fuel gases. Flames.

B. Equipment

See the relevant parts (chemicals and supplies in the secondary schools inventories for general science equipment on page 29.)

6. TECHNICAL DRAWING

These courses are true specialization courses for each vocational purpose. By way of example, a metalwork and a woodwork vocational school is presented.

A. Course Content

(a) General

Use of drawing instruments and materials. Conventional representation. Plane graphics: plane curves. Space graphics: orthogonal projection, dimensions, pictorial view, sectional views.

Descriptive geometry. Fundamentals, descriptive geometry methods, representation of the point, line, plane, circle, of simple geometrical solids, helical surfaces. Intersections.

Free-hand sketches, transformation exercises, sketching from memory, reading of blue-prints.

(*b*) *Metalwork*

Free-hand sketches of machine parts. Study of transformation. Simple studies of machine parts or tools. Sketches from memory, lecture of blue prints, working drawings of machine parts, machine elements, gearing, frames.

(*c*) *Woodwork*

Free-hand sketches and working drawings of simple joinery; simple studies of doors, windows, shop-windows, etc.

B. VOCATIONAL SCHOOL EQUIPMENT FOR TECHNICAL DRAWING (100 pupils)

Quantity	Item	Total cost in dollars
3	Blackboard dividers, 50 cm	7.50
3	Blackboard drawing sets	13.50
1	Blue print duplicator	225.00
100	Drawing boards 40 × 60 cm	
1	Cone, dissectible	9.75
20 pkg	Crayons, coloured	5.00
1 set	Geometrical, curves, solids and surfaces	4.00
1 set	Models various machine parts	—
1	Pantograph	10.00
1	Planimeter	48.00
2 sets	Protractors, full circle	56.00
1	Rule, carpenter's, 2 m length	1.25
2	Rules, parallel, blackboard	12.00
1	Rule, slide for demonstration, 1.50 m length	10.00
1	Straight edge, steel, 1.50 m	16.00
1	Tape, flexible steel, 1 m	10.00
12	Triangles, celluloid, 30° × 60° and 45°	15.00
2	Trigonometric function demonstration boards (sine, cosine, tangent)	35.00
	Total	478.00

7. TECHNOLOGY AND WORKSHOP PRACTICE FOR METAL AND WOODWORK

A. COURSE CONTENT

(*a*) *Courses common to both specialities*

Elementary study of essential engineering materials. Quality and prices. Transformation of raw materials, general principles of manufacture, handwork, tools; machinework, machine-tools.

General characteristics of machinery. Principal machine tools for wood and metalwork. Operation. Protection against accidents.

(*b*) *Metalwork*

(i) Lectures:

Metals. Mechanical characteristics, resistance, resilience, mechanical tests, thermal treatment. Welding.

Design of machine parts. Bolts and nuts. Stud bolts, pins, washer; rivets. Various joints. Shafts, coupling of shafts, gudgeons, bearings, thrust-bearings, ball and cylinder bearings.

Transmissions, belts, cables, chains. Pulleys, gearing. Rods, connecting rods, cranks, cams. Pistons, piston-rings and packing, guides, slides, slide-blocks. Lubrication. Pipes joints, stopcocks, cut-offs, valves.

Design of frames, fastenings and simple machine elements for steam and internal combustion engines. Lifting and mechanical handling machines. Compressors and blowers.

Tools. Tool steel, cutting metals, speed of cut. Study of various tools: lathe-tools, screw-cutting tools; screw-stocks and taps, drilling tools, twist-drill, special drills, reamers, blade reamers, counter-sinks, planing tools, slotting tools, sawing tools. Cutting and stamping tools, grinders.

Tracing, measuring lengths and angles, tolerances, standards, calipers. Basic machine tools:

1. Continuous rotation of part: lathe, sliding and screw-cutting lathe, face-lathe, cutting-off lathe, simple and automatic.
2. Continuous rotation of tool: drill, screwing-machine, drilling machine, milling machine.
3. Alternative motion machines: shaping machine, planing-machine, slotting machine.
4. Abrasive tool machines: rough grinders, sharpening-machine, grinding-machine.

(ii) Workshop practice:

Tracing, fitting, planing, slotting, chucking, turning, cylindrical and surface grinding, milling, screw-cutting, tapping, drilling, reaming, shaping, etc.

Mechanical workshop organization.

(*c*) *Woodwork*

(i) Lectures:

Wood. Structure, constitution, growth defects. Mechanical and physical properties of wood, density, moisture content, volume change, colour, preservation treatments.

Classification, lumbering, cubage.

Machines. Circular, band, alternating saws. Cutting, veneer-cutting, unrolling, trimming, planing machines, spindle moulding machines. Lathes, recessing machines, boring, mortizing, tenoning machines. Finishing, sandpapering machines.

Organization of a joiner's, cabinet maker's wood pattern workshop.

(ii) Workshop practice:

Hand tools. Bench and cutting tools, shaping and jointing tools, boring tools, box screw, gauge, mortize-chisel, planishing tool. Measuring and tracing instruments.

Joining of timbers. Glue.

Machines: machinework, accidents, protection. Wood painting, coating, varnishing, waxing, colouring. Veneering.

Usual dimensions of timber.

Conservation of sawn timber.

For joiners:

Description, lay-out and execution of doors, windows, shutters, floors, skirting-boards, panels, trailing edge strips, staircases.

Measuring and evaluating joiner's work.

For cabinet makers:

Description, lay-out and execution of the main pieces of furniture. Use of mouldings, decoration. Cost price of a piece of furniture.

For foundry pattern makers:

Moulding. Pattern, core print, core-box, simplified patterns, strickling. Execution of various patterns of machine parts.

B. EQUIPMENT FOR METALWORK AND WOODWORK

(*a*) *Metalwork*

(i) Demonstration (100 pupils)

Quantity	Item	Total cost in dollars
1 set	Bearings	20.00
1 set	Bolts	5.00
1	Cam and yoke	25.00
1	Comparator	150.00
1	Composition of forces, board	7.00
1 set	Connecting-rods	20.00
1 set	Couplings: flange coupling, collared-coupling, friction-coupling, claw-coupling	50.00
1	Crank	10.00
1	Crank, Le Hire's	15.00
1	Engine, aircraft, model	50.00
1	Engine, automobile, model	40.00
1	Engine, Diesel, model	40.00
1	Gear-box, model	12.00
1 set	Gear-wheels	20.00
1	Heart, cam	10.00
1	Joint, Cardan	10.00
1 set	Length standards, Johansson's	50.00
1	Lozenge, Peaucellier's	6.00
1 set	Lubricators	10.00
1	Mechanical testing machine	3,000.00
1	Microscope, metallographic	400.00
1	Parallelogram, Watt's model	8.00
1	Pendulum, Charpi's	500.00
1 set	Pistons	25.00
1	Plate surface, standard	30.00
1 set	Pulleys	25.00
1	Screw, worm and wheel	10.00
1	Speed-indicator	15.00
1	Testing machine, Brinell's	1,500.00
1	Testing machine, Rockwell's	750.00
	Total	6,813.00

(ii) Workshop Machines (100 pupils)

2	Blow torches	25.00
2	Calipers, depth	7.00
2	Calipers, inside	4.00
1 set	Calipers, micrometer, machine	30.00
2	Calipers, outside	4.00
1	Drill press, high speed, light	200.00
1	Drill press, medium	500.00
1	Forge with anvil	150.00
1	Furnace, gas	150.00
1	Gauge, drill	3.00
1	Grinding machine, truing type, simple	1,000.00
1	Grinding machine, surface	1,500.00
1	Grinding machine, universal	2,000.00
12	Lathes, height less than 200 mm	3,600.00
3	Lathes, height more than 200 mm	2,000.00
1	Lathe, semi-automatic, turret	1,000.00
2	Milling machines, semi-universal horizontal and vertical	250.00
2	Milling machines, simple horizontal	750.00
2	Milling machines, simple vertical	750.00
1	Milling machine, universal	1,000.00
	Carried forward	14,923.00

Quantity	Item	Total cost in dollars
	Brought forward	14,923.00
1	Planing machine	400.00
4	Rules, metal, 1 ft long graduated to 1/64 in	8.00
1	Sawing machine	100.00
3	Shaping machines	2,000.00
1	Sharpening machine	200.00
1	Slotting machine	500.00
1	Surface plate	45.00
1	Trimming wheel	50.00
1	Grinder tool with attachments	150.00
	Total	18,376.00

(iii) Workshop Tools (for 100 Pupils)

Quantity	Item	Total cost in dollars
5	Angle plates, 15 × 12.5 × 10 cm, planed all over	36.00
5	Anvils and blocks, 50 kg	160.00
2	Bellows, foot 25 cm	35.00
180	Blades, hacksaw	15.00
10	Blocks, lead 10 × 10 cm	5.00
5	Blow pipes, diam 10 mm with 2.5 m tubing for each	35.00
25	Brushes, bench	37.50
5	Calipers	10.00
15	Chisels, cold, 15 mm	3.00
15	Chisels, cold, 20 mm	4.00
5	Clamps, toolmaker's	15.00
15	Compasses, wing	10.50
15	Dividers, spring, 15 cm	5.00
5	Drills, bench, 12.5 mm	110.00
10	Drills, hand	15.00
20	Drills, twist, various sizes	25.00
50	Files, 25 cm, bastard	5.00
50	Files, 25 cm, flat and half round	7.00
25	Files, 25 cm, round	6.00
50	Files, 20 cm, second cut, flat	5.00
50	Files, 20 cm, second cut, half round	3.50
25	Files, 15 cm, smooth cut	3.00
25	Files, 20 cm, smooth cut	4.50
25	Files, 25 cm, square	5.00
25	Files, 15 cm, triangular	4.00
25	Files, 10 cm, ward, assorted	2.00
5 pr	Goggles, safety glass	10.00
5	Grinders	10.00
100	Hammers, 400 g	200.00
100	Hammers, 1 kg	100.00
360	Handles	70.00
2	Hearths, brazing	375.00
5	Horses, tinman's	12.00
15	Irons, soldering	15.00
5	Kettles	5.00
10	Mallets, bossing, boxwood	6.00
10	Mallets, cylinder, boxwood, diam 5 cm	5.00
5	Mallets, hide	7.00
5 sets	Numbers and letters	35.00
5	Oil feeders	6.00
5	Oil stones in cases	10.00
5	Pails	4.25
10	Pliers, flat nose, 12.5 cm	10.00
10	Pliers, round nose, 12.5 cm	10.00
50	Punches, centre	10.00
	Rivets, 3 and 5 mm	3.00
	Carried forward	1,469.25

Quantity	Item	Total cost in dollars
	Brought forward	1,469.25
100	Rules, steel, 30 cm	6.00
2	Sand bags, leather, 25 cm	15.00
15	Saws, hack	15.00
5	Screw drivers, 75 mm	2.50
5	Screw drivers, 150 mm	6.00
100	Scribers	25.00
5	Shears, bench	60.00
5	Snips, tinman's	10.00
5	Spanners, 15 cm	10.00
1000	Squares, 10 cm	6.00
30	Stake heads, assorted, 2 kg each	35.00
5 sets	Stocks and dies, BA 0-10	160.00
5 sets	Stocks and dies, Whit. ¼-½ in	
5	Stoves, soldering	60.00
5	Surface plates, 30 × 30 cm, with cover	160.00
5 sets	Taps, BA 0-10	125.00
5 sets	Taps, Whit. ¼-½ in	
5	Tongs, Smith's	10.00
5	Troughs, earthenware	80.00
1	Vice for drilling machine	15.00
5	Vices hand, 10 cm	15.00
100	Vices, bench, 10 cm	100.00
	Total	2,384.75

(*b*) *Woodwork*

(i) Workshop Machines (for 30 pupils)

1	Boring machine	150.00
1	Grinder, power with attachments	125.00
1	Grindstone	25.00
1	Lathe, surface and boring	400.00
4	Lathes, wood-turning	600.00
1	Mortizing machine attachment to bench saw	50.00
1	Planer, 50 cm	200.00
1	Recessing machine	100.00
1	Sand papering machine, belt	95.00
1	Saw, band, tilting table	150.00
1	Saw, circular, tilting table	150.00
1	Spindle moulding machine, with tolls for tenoning and dovetailing	300.00
1	Surface planing machine, jointer with motor	250.00
1	Wood trimming machine	120.00
	Total	2,715.00

(ii) Workshop Tools (for 30 pupils)

4	Bevels, 25 mm	3.00
30	Bits, centre, various sizes, 8-30 mm	8.00
3	Bits, countersink, 10 mm	·75
6	Bits, dowel, various sizes 8-15 mm	4.00
1	Bowl, enamelled	1.00
4	Braces, joiner's, plain	7.00
1	Brace, ratchet type, 25 cm	5.00
9	Bradawls	1.00
15	Brushes, bench	3.75
3	Cabinet scraper blades, and sharpener	5.00
4	Chisels, firmer, 3 mm	2.00
120	Chisels, firmer, various sizes, 5-20 mm	10.00
15	Chisels, firmer, 25 mm	3.00
	Carried forward	53.50

Quantity	Item	Total cost in dollars
	Brought forward	53·50
6	Chisels, mortize, 6 mm	4.00
3	Chisels, mortize, 8 mm	4.00
3	Chisels, mortize, 10 mm	4.00
15	Clamps, steel, various sizes, 20-120 cm	25.00
1	Compass, blackboard, 45 cm	4.00
2	Compasses, blackboard, 20 cm wing	2.00
3	Dividers, spring	2.10
30	Drawing boards, 40 × 60 cm	36.00
6	Files, cabinet makers, half round, 25 mm	1.80
9	File handles	·75
1	Gauge, cutting	·75
30	Gauges, making	7·50
3	Gimlets	.60
2	Glue pots	4.00
2	Gouges, firmer, 12 mm	2.00
2	Gouges, firmer, 18 mm	2.50
1	Grindstone with iron trough	56.00
15	Hammers	30.00
3	Handscrews	2.25
9	Irons, cutting for jack plane, 60 mm	2.70
1	Kettle	·75
15	Mallets, small, 10 cm	6.00
2	Oil feeders, bench, small	.60
2	Oilstones, India, fine and coarse	3.00
3	Pincers, 15 cm	1.20
30	Planes, jack	145.00
1	Plane, plough	7·20
1	Plane, rebate	3·50
3	Planes, smoothing metal	7·50
1	Plane, trying	11.00
30	Punches, brad	3.00
1	Punch, rivet	·50
2	Rules, boxwood, 4 fold	1.90
30	Rules, steel, 30 cm	15.00
6	Saws, bow, 20 cm	9.00
2	Saws, bow 30 cm	4.00
3	Saws, dovetail, 20 cm	2.75
6	Saws, hand, 55 cm	12.00
1	Saw, hand half rip	5.00
10	Saws, tenon	10.00
15	Screw drivers, large, 25 cm	7·50
6	Screw drivers, small, 10 cm	1.20
1 set	Squares, framed, 45 cm, 45°	5.00
1 set	Squares, framed, 45 cm, 60°	5.00
4	Spokeshaves, flat face	2.25
4	Spokeshaves, round face	2.25
30	T-squares, 60 cm	30.00
1	T-square, 100 cm	4.00
1	Thermometer, indoor	1.00
30	Try-squares, 15 cm	12.00
1	Try-square, 25 cm	2.50
1 set	Wood lath tools	12.50
	Total	579·55

APPENDIX

ABBREVIATIONS

A — ampere
AC — alternating current
Ah — ampere-hour
AR — analytical reagent
asst — assortment
asyn — asynchronous
BA — British Association
BC — bayonet cap
bk — book
bp — boiling point
C — celcius
cc — cubic centimetre
cm — centimetre
comml — commercial
conc — concentrated
conv — convergent
cp — chemically pure
cryst — crystalline
c/s — cycle per second
cwt — hundredweight
DC — direct current
demn — demonstration
diam — diameter
dil — dilute
div — divergent
dm — decimetre
doz — dozen
dr — drachm
elem — elements
EMF — electromotive force
expt — experiment
f — focus
F — Fahrenheit
FB — flat bottom
FBL — flat bottom, lipped
fp — freezing point
ft — foot, feet
g — gramme
gal — gallon
gran — granulated
h — hour
HF — high frequency
HP — horse power
id — internal diameter
Imp — imperial
in — inch
kg — kilogramme
km — kilometre
kVA — kilovoltampere
kW — kilowatt
l — litre
L — lipped
lb — pound
LF — low frequency
m — metre
mA — milliampere
max — maximum
μA — microampere
μF — microfarad
μμF — micromicrofarad
mg — milligramme
mH — milliheury
min — minute
mm — millimetre
mμ — millimicron
mp — melting point
NMFS — narrow mouth, flat stopper
oz — ounce
pkg — package
powd — powder
pptd — precipitated
pr — pair
pt — pint
RB — round bottom
RMS — root mean square
rpm — revolutions per minute
s — second
SBC — small bayonet cap
sg — specific gravity
soln — solution
sq — square
SWG — standard wire gauge
syn — synchronous
tech — technical
V — volt
W — watt
winch — Winchester quart
WMBSC — wide mouth, bakelite screw cap
yd — yard

APPENDIX II

CONVERSION FACTORS

Length

1 mm = 0.03937 in
1 cm = 0.3937 in
1 m = 3.2808 ft
= 1.0936 yd
1 km = 0.6213 mile

1 mil = 1/1000 in
= 0.0254 mm
1 in = 25.4 mm
1 ft = 12 in
= 30.48 cm
1 yd = 3 ft
= 0.9144 m
1 mile = 1609.3 m
1 line = 1/12 in
= 2.116 mm

Surface

1 mm^2 = 1973.5 circular mils
1 cm^2 = 0.155 in^2
1 m^2 = 10.7639 ft^2
= 1.1959 yd^2
1 km^2 = 0.3861 mile^2
= 247.11 acres
1 hectare = 2.4711 acres

1 circular mil = 0.0005067 mm^2
1 in^2 = 6.4516 cm^2
1 ft^2 = 144 in^2
= 0.0929 m^2
1 yd^2 = 9 ft^2
= 0.83613 m^2
1 acre = 4046.9 m^2
1 mile^2 = 1640 acres
= 2.5899 km^2

Volume

1 ml = 1 cm^3 = 0.06102 in^3
1 l = 1 dm^3 = 0.0353 cubic feet
1 m^3 = 35.3156 ft^3
= 1.3079 yd^3

1 in^3 = 16.387 cm^3
1 ft^3 = 28.317 dm^3
1 yd^3 = 0.76456 m^3

Capacity

1 l = 35.196 British fluid ounces
= 1.75981 British pints
= 0.2199 British gallons

= 33.8140 U.S. fluid ounces
= 2.1134 U.S. pints
= 0.2642 U.S. gallons

1 British fluid ounce = 0.0284 l
1 British pint = 0.5682 l
1 British imperial gallon = 8 British pt
= 4.5459 l
1 U.S. fluid ounce = 0.02957 l
1 U.S. pint = 0.4732 l
1 U.S. gallon = 3.7854 l
1 Winchester-quart = 80 British fluid ounces = 2.2729 l

Weight

1 g = 0.035 oz
1 kg = 35.273 oz
= 2.2046 lb

1 oz = 28.35 g
1 lb = 453.5 g
1 cwt = 50.802 kg
1 oz troy = 31.103 g

Power

1 kW = 1.341 HP

1 HP = 0.7457 kW

Pressure

1 kg/cm^2 = 14.223 lb/in^2

1 lb/in^2 = 0.070307 kg/cm^2
= 95.760 pz

WIRE GAUGES

No.	Imp. Std. Wire Gauge (IWG or SWG) DIAMETER in	mm	American Wire Gauge (AWG or Brown and Sharpe's Gauge) DIAMETER in	mm	U.S. Govt. Std. Gauge 1893 DIAMETER in	mm	Birmingham Wire Gauge (BWG) DIAMETER in	mm
00000	0.432	10.973			0.4375	11.112		
0000	0.400	10.160	0.460	11.684	0.40625	10.319	0.454	11.532
000	0.372	9.449	0.4096	10.404	0.375	9.525	0.425	10.795
00	0.348	8.839	0.3648	9.266	0.3437	8.731	0.38	9.652
0	0.324	8.229	0.3249	8.252	0.3125	7.938	0.34	8.636
1	0.300	7.620	0.2893	7.348	0.2812	7.144	0.300	7.620
2	0.276	7.010	0.2576	6.543	0.2656	6.747	0.284	7.214
3	0.252	6.401	0.2294	5.827	0.250	6.35	0.259	6.579
4	0.232	5.893	0.2043	5.189	0.2344	5.953	0.238	6.045
5	0.212	5.385	0.1819	4.620	0.2186	5.556	0.220	5.588
6	0.192	4.877	0.1620	4.115	0.2031	5.159	0.203	5.156
7	0.176	4.470	0.1443	3.665	0.1875	4.763	0.18	4.572
8	0.160	4.064	0.1285	3.264	0.1719	4.366	0.165	4.191
9	0.144	3.658	0.1144	2.906	0.1562	3.969	0.148	3.759
10	0.128	3.251	0.1019	2.588	0.1406	3.572	0.134	3.404
11	0.116	2.946	0.09074	2.305	0.125	3.175	0.12	3.048
12	0.104	2.642	0.08081	2.053	0.1094	2.778	0.109	2.769
13	0.092	2.337	0.07196	1.828	0.0937	2.381	0.095	2.413
14	0.080	2.032	0.06408	1.628	0.0781	1.984	0.083	2.108
15	0.072	1.829	0.05707	1.450	0.0703	1.786	0.072	1.829
16	0.064	1.626	0.05082	1.291	0.0625	1.588	0.065	1.651
17	0.056	1.422	0.04526	1.150	0.0562	1.429	0.058	1.473
18	0.048	1.219	0.04030	1.024	0.05	1.27	0.049	1.245
19	0.040	1.016	0.03589	0.912	0.0437	1.111	0.042	1.067
20	0.036	0.914	0.03196	0.812	0.0375	0.952	0.035	0.889
21	0.032	0.813	0.02846	0.723	0.0344	0.873	0.032	0.813
22	0.028	0.711	0.02535	0.644	0.03125	0.794	0.028	0.711
23	0.024	0.610	0.02257	0.573	0.0281	0.714	0.025	0.635
24	0.022	0.559	0.02010	0.511	0.025	0.635	0.022	0.559
25	0.020	0.508	0.01790	0.455	0.0219	0.556	0.02	0.508
26	0.018	0.457	0.01594	0.405	0.0188	0.476	0.018	0.457
27	0.0164	0.4166	0.01420	0.361	0.0172	0.437	0.016	0.406
28	0.0148	0.3759	0.01264	0.321	0.0156	0.397	0.014	0.356
29	0.0136	0.3454	0.01126	0.286	0.0141	0.357	0.013	0.330
30	0.0124	0.3150	0.01003	0.255	0.0125	0.318	0.012	0.305
31	0.0116	0.2946	0.008928	0.227	0.0109	0.278	0.010	0.254
32	0.0108	0.2743	0.007950	0.202	0.0102	0.258	0.009	0.229
33	0.0100	0.2540	0.007080	0.180	0.0094	0.238	0.008	0.203
34	0.0092	0.2337	0.006304	0.160	0.0086	0.218	0.007	0.178
35	0.0084	0.2134	0.005615	0.143	0.0078	0.198	0.005	0.127
36	0.0076	0.1930	0.005000	0.127	0.00703	0.179	0.004	0.102
37	0.0068	0.1727	0.004453	0.113	0.00664	0.169		
38	0.0060	0.1524	0.003965	0.101	0.00625	0.159		
39	0.0052	0.1321	0.003531	0.090				
40	0.0048	0.1219	0.003145	0.080				

SCREW THREADS

International standard metric screw threads (60°).

Diameter of screw in mm	Pitch mm
6	1.00
7	1.00
8	1.25
9	1.25
10	1.50
11	1.50
12	1.75
14	2.00
16	2.00
18	2.50
20	2.50
22	2.50
24	3.00

British and American national screw threads (Sellers thread) (60°)

Diameter of screw in inches	Threads per inch	Diameter of screw in inches	Threads per inch
1/4	20	9/16	12
5/16	18	5/8	11
3/8	16	3/4	10
7/16	14	7/8	9
1/2	13	1	8

British Association screw threads (47½°)

Number	Diameter of screw mm	inches	Pitch mm
0	6.0	0.236	1.00
1	5.3	0.209	0.90
2	4.7	0.185	0.81
3	4.1	0.161	0.73
4	3.6	0.142	0.66
5	3.2	0.126	0.59
6	2.8	0.110	0.53
7	2.5	0.098	0.48
8	2.2	0.087	0.43
9	1.9	0.075	0.39
10	1.7	0.067	0.35

Whitworth standard screw threads (55°)

Diameter of screw in inches	Threads per inch	Diameter of screw in inches	Threads per inch
1/4	20	5/8	11
5/16	18	11/16	11
3/8	16	3/4	10
7/16	14	13/16	10
1/2	12	7/8	9
9/16	12	1	8

THE ELEMENTS[1]

		Atomic Number	Atomic Mass
(Nn	Neutron	0	1.0088)
H	Hydrogen	1	1.0080
He	Helium	2	4.003
Li	Lithium	3	6.940
Be	Beryllium	4	9.02
B	Boron	5	10.82
C	Carbon	6	12.010
N	Nitrogen	7	14.008
O	Oxygen	8	16
F	Fluorine	9	19.00
Ne	Neon	10	20.183
Na	Sodium	11	22.997
Mg	Magnesium	12	24.32
Al	Aluminium	13	26.97
Si	Silicon	14	28.06
P	Phosphorus	15	30.974
S	Sulphur	16	32.066
Cl	Chlorine	17	35.457
A	Argon	18	39.944
K	Potassium	19	39.096
Ca	Calcium	20	40.08
Sc	Scandium	21	45.10
Ti	Titanium	22	47.90
V	Vanadium	23	50.95
Cr	Chromium	24	52.01
Mn	Manganese	25	54.93
Fe	Iron	26	55.85
Co	Cobalt	27	58.94
Ni	Nickel	28	58.69
Cu	Copper	29	63.542
Zn	Zinc	30	65.377
Ga	Gallium	31	69.72
Ge	Germanium	32	72.60
As	Arsenic	33	74.91
Se	Selenium	34	78.96
Br	Bromine	35	79.916
Kr	Krypton	36	83.7
Rb	Rubidium	37	85.48
Sr	Strontium	38	87.63
Y	Yttrium	39	88.92
Zr	Zirconium	40	91.22
Nb	Niobium	41	92.91
Mo	Molybdenum	42	95.95
Tc	Technetium	43	98.91
Ru	Ruthenium	44	101.7
Rh	Rhodium	45	102.91
Pd	Palladium	46	106.7
Ag	Silver	47	107.880
Cd	Cadmium	48	112.41
In	Indium	49	114.76
Sn	Tin	50	118.70
Sb	Antimony	51	121.76
Te	Tellurium	52	127.61
I	Iodine	53	126.92
Xe	Xenon	54	131.3
Cs	Caesium	55	132.91
Ba	Barium	56	137.36
La	Lanthanum	57	138.92
Ce	Cerium	58	140.13
Pr	Praseodymium	59	140.92
Nd	Neodymium	60	144.27
Pm	Promethium	61	147
Sm	Samarium	62	150.43
Eu	Europium	63	152.0
Gd	Gadolinium	64	156.9
Tb	Terbium	65	159.2
Dy	Dysprosium	66	162.46
Ho	Holmium	67	164.94
Er	Erbium	68	167.2
Tm	Thulium	69	169.4
Yb	Ytterbium	70	173.04
Lu	Lutecium	71	175.0
Hf	Hafnium	72	178.6
Ta	Tantalum	73	180.88
W	Tungsten	74	183.92
Re	Rhenium	75	186.31
Os	Osmium	76	190.2
Ir	Iridium	77	193.1
Pt	Platinum	78	195.23
Au	Gold	79	197.2
Hg	Mercury	80	200.61
Tl	Thallium	81	204.39
Pb	Lead	82	207.21
Bi	Bismuth	83	209.00
Po	Polonium	84	210
At	Astatum	85	210
Rn	Radon	86	222
Fr	Francium	87	221
Ra	Radium	88	226.05
Ac	Actinium	89	227
Th	Thorium	90	232.12
Pa	Protactinium	91	231
U	Uranium	92	238.07
Np	Neptunium	93	237.07
Pu	Plutonium	94	239.08
Am	Americium	95	243
Cm	Curium	96	244
Bk	Berkelium	97	245
Cf	Californium	98	(246)
		99	
Ct	Centurium	100	(248)

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[1] We are indebted to Mr. Grégoire of the *Institut du Radium* (Paris) who kindly gave us the latest data concerning atomic masses.

APPENDIX III

SHORT LIST OF SUPPLIERS OF SCIENTIFIC INSTRUMENTS

AUSTRALIA

Abacus Instrument Co.
122 King St.
Melbourne

Dobbie Bros. (Thermometers)
80 Little Lonsdale St.
Melbourne

BELGIUM

Fédération des entreprises de l'industrie des fabrications métalliques
17, Rue des Drapiers
Brussels

Société belge d'optique et d'instruments de précision
110, Rue de la Prairie
Ghent

DENMARK

Association of Scientific Instrument Manufacturers Industriraadet
18 Vestre Boulevard
Copenhagen 5

H. Struers Chemiske Laboratorium
38 Skindergade
Copenhagen

FRANCE

Association interprofessionnelle des constructeurs de matériel d'équipement scientifique (AICMES) (12 member federations comprising 165 firms)
105, Rue La Fayette
Paris, 10e

FOPEX (group of 32 industrials)
105, Rue La Fayette
Paris, 10e

GREAT BRITAIN

Scientific Exports (Great Britain) Ltd. (SCIEX) (comprising 7 firms)
Buckingham House, Buckingham St.
Adelphi, London, W.C.2

Scientific Instrument Manufacturers' Association of Great Britain Ltd. (SIMA) (comprising 84 firms)
17 Princes Gate
London, S.W.7

ITALY

Associazione nazionale degli industriali del vetro
2 Via Regina Elena
Rome

Associazione nazionale industria meccanica e metallurgica
3 Piazza Mignanelli
Rome

NETHERLANDS

Vereeniging van Nederlandsche Instrumentfabrikanten
73 Voorstraat
Delft

SWEDEN

Rudolph Grave Aktiebolaget
48 C Malmskillnadsgatan
Stockholm

Norstedt & Soner
17 Bryggaregatan
Stockholm

Axel Kistner
20-22 Wallingatan
Stockholm

SWITZERLAND

Association suisse des constructeurs de machines (VSM)
4, General Wille Strasse
Zürich 2

UNITED STATES

Scientific Apparatus Makers of America (SAMA) (comprising 202 firms)
20 N. Wacker Drive
Chicago 6, Illinois

U.S. Scientific Export Association Inc.
50 Broadway
New York, N.Y.

APPENDIX IV

RECOMMENDATIONS OF THE TWELFTH INTERNATIONAL CONFERENCE ON PUBLIC EDUCATION—JULY 1949

The new approach to revitalize the educative processes by the extensive use of science and scientific methods was discussed by the official representatives of 47 countries who attented the Twelfth International Conference on Public Education convened in Geneva by Unesco and IBE in July 1949. The Conference issued the following comprehensive recommendations concerning the introduction of natural sciences in primary schools to the Ministries of Education of the various countries:

The Conference,

Bearing in mind that the encouragement of the scientific spirit of observation and experiment, through the spontaneous interests of children, is one of the foremost aims of education, and that the introduction to natural science is particularly suitable as an instrument for such training,

Bearing in mind also that it is necessary to associate schools in common action for the protection of nature,

Submits to the Ministries of Education of the various countries the following recommendations:

1. That natural science be introduced as from the first classes of the primary school;
2. That, even if such introductory study is given as a separate subject, natural science be nevertheless correlated with the teaching of other subjects (language, drawing, handicrafts, etc.);
3. That this introduction to natural science achieve the following objectives:
    (a) Develop a child's intellect by the use of activity methods based as far as possible on individual observation and experiment;
    (b) Stimulate the imagination and sensitiveness of a school-child by making him love nature and her beauties and by interesting him in natural phenomena and the various manifestations of life;
    (c) Support and foster all activity tending to protect and conserve nature;
4. That, since an introduction to natural science in primary schools should be based on observation and experiment, the following be made available in and out of school, for the use of the children, without restricting their own initiative:
    (a) Optical instruments (magnifying glasses, etc.), terraria, aquaria, school-gardens, etc. (wherever direct observation is feasible), and
    (b) Educational films, slides, wall pictures and collections (wherever for any reason direct observation is impossible);
5. That children be trained to undertake group research and to check each other's observation and interpretation of facts;
6. That such research go hand in hand with expression in picture and word;
7. That children be encouraged to collect things for the class or school museum for which they will have vivid feelings of personal attachment through thus having contributed to it;
8. That support be given to organizing lessons in the open air, which lend themselves especially well to really educational teaching of natural science, and which conform to the demands of educational theory;
9. That preference be given always, not to the morphological or descriptive, but to the functional method, the method which studies the organs and structure of living creatures, in connexion with life, with other living creatures, and with the problems of the locality; and that living creatures never be observed as isolated units;
10. That teaching of natural science never begin with lists of names, definitions, classifications, laws, etc., as these should rather be the end products of observation and experiments which the children have themselves made, and of the knowledge they already possess;
11. That, without prejudice to the above points, curricula be flexible enough to allow for the adaptation of teaching to local resources;

12. That, furthermore, if the locality itself is not able to provide certain objects needed for observation, the children be enabled to procure them through inter-school exchanges;
13. That the books used for teaching consist above all of books containing information so written that it stimulates the children to inquire and observe for themselves;
14. That, among out-of-school activities (walks, excursions, nature clubs), special preference be given to those tending to develop a love of nature and a desire to conserve natural resources by such means as reforestation, the protection of plants and animals, and the battle against erosion;
15. That teachers occasionally describe how scientific discoveries have been made, and tell their pupils something of the lives of those who have contributed to the advance of science throughout the world;
16. That special attention be paid to the training of teachers, in order that they may be informed of the various methods of teaching natural science, and of such phases of a child's intellectual development as may prove of use in their work;
17. That periodical meetings, conferences and refresher courses keep teachers in touch with developments in science and educational theory and method, and with the results of experiments in the teaching of natural science.

APPENDIX V

BIBLIOGRAPHY

The following is a short list for further reading. Some of the books relate directly to scientific apparatus; the rest are recent publications on course content or method. The list is representative and by no means exhaustive.

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PRIMARY SCHOOLS

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Sloan Project in Applied Economics, 280 Madison Avenue, New York 16, N.Y., U.S.A. (School readers' and teachers' manuals developed in projects of community-centred education.)

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Syllabuses. Much excellent material is put out by the State Boards of Education in U.S.A. Further data from U.S. Office of Education, Washington, D.C., U.S.A. Some typical examples are:

Elementary Teachers' Handbook. Vol. 5. Science and Nature Study. Iowa Dept. of Public Instruction. 1943. Des Moines, Iowa, U.S.A. 118 pp.

Course of Study for Elementary School Science, Health and Agriculture. Montana State Dept. of Public Instruction. 1946. Published by Tribune Printing and Supply Co., Great Falls, Montana, U.S.A. 120 pp.

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SECONDARY SCHOOLS

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APPENDIX VI

SCIENCE CLUBS AND OTHER YOUTH ACTIVITIES

In July 1949 Unesco convened an international meeting of Science Club Leaders in Paris. The final report is of interest:

The Meeting of Science Clubs

Considering:

the undoubted value of science clubs in awakening, guiding, developing and stimulating young people's interest in scientific and technical activities;

the attraction they hold for young people as an opportunity for voluntary rather than compulsory activities;

the opportunity thus provided to acquaint them, on the one hand, with nature, its laws, phenomena, resources and man's mastery of nature, and on the other, with the technical achievements which are a distinctive feature of modern life;

the value of developing, especially in the country, the practical application of science and of giving to young workers broader knowledge which would enable them to better understand their trade, perfect themselves in it, and help them find better employment;

the valuable results—particularly the raising of the standards of scientific study, adaptation to the requirements of modern life, selection for scientific and technical careers, especially the moulding of research workers—which have already been observed in the United States of America and a few other countries;

and lastly, the benefits which would ensue for strengthening and maintaining future peace by the awakening of a common interest, the discovery of scientific truths, and the organization of common activities and research among young people of all countries,

Proposes that Unesco

1. Take appropriate steps to recommend to the Governments of its Member States, through their National Commissions where possible:

that science clubs, which represent a form of activity of general interest be given effective support and in particular that they benefit by financial assistance from governments, public authorities, and other organizations;

that the establishment, if necessary, and in any case the development, of such clubs be systematically considered and organized;

that the public authorities facilitate such establishment and development and with this in view convene in each country where the science club movement has not yet reached an active phase, a conference to discuss the problems relating to these clubs. Representatives of qualified and interested administrative, academic, teaching, and scientific organizations as well as the representatives of youth would participate in this conference. Suggested among the measures which could be considered in this connexion are:

(a) a study of primary and secondary school curricula with a view to reducing, if necessary, the number of compulsory school hours to permit more free time for science clubs;
(b) urging of school teachers and administrators to take the necessary steps to encourage science clubs and, until the young people have chosen their leaders, to set them up;
(c) giving of effective assistance in training of specialized instructors necessary for the development of these clubs;
(d) utilization by science clubs of laboratories or technical apparatus which is necessary for their work;
(e) utilization in this connexion of all means of dissemination and in particular the radio, press, and film;

that National Associations for the Advancement of Science be informed of this interesting problem, either individually or collectively;

that in general, every facility and encouragement be offered to youth movements, institutions and organizations, and associations of pupils, former pupils, and others, to introduce science clubs as part of their activities.

2. Take an active part in such work in every possible way, in particular by establishing for this purpose a permanent control office of information and by instigating the sponsorship by existing active clubs and of clubs to be founded or developed in other countries.

The Meeting of Science Club Leaders,

Recognizing the strong moral and material influence of science on the everyday life of modern society, and realizing the vital importance of an appreciation by all of the value of science devoted to peaceful ends as a force making for human progress, and that peace is essential to scientific advance,

Recommends that science clubs should concern themselves with the study and spreading of scientific method and the social implications of science. To further this, among other things, the science clubs should, through their Unesco National Commission, link themselves up actively with the recurring annual Unesco discussion theme and consider the organizing of essay competitions and exhibitions to illustrate this theme.

Further information about science clubs may be obtained from Unesco's Department of Natural Science. Readers may wish, however, to get in touch with organizations actively working in the field. The list that follows is by no means comprehensive but it may suggest useful sources of practical information.

Science Clubs

Science Service, 1719 N Street N.W.,
Washington 6, D.C., U.S.A.

Assuit College, Assuit, Egypt.

County Grammar School for Boys,
Holmes Avenue, Hove 4, England.

Jeunesse Astronomique de France,
17, Rue Deutsch-de-la-Meurthe,
Paris 14, France.

Many vigorous youth associations are formed around the centres of interest provided by farming and nature study.

4-H Clubs

Association Forestière Québecoise,
Clubs 4-H du Québec Inc.,
286, Rue St-Joseph, Québec, Canada.

Jamaican Agricultural Society,
Kingston, Jamaica, B.W.1.

U.S. Department of Agriculture,
Extension Service,
Washington 25, D.C., U.S.A.
(Very full data on programmes developed in separate States.)

Young Farmers' Clubs

Young Farmers' Club Association,
Victoria, Australia.

National Federation of Young Farmers' Clubs,
Ministry of Agriculture, United Kingdom.

Agricultural Education Service,
U.S. Office of Education,
Washington, D.C., U.S.A.
(For Future Farmers of America, New Farmers of America and similar activities.)

Other Science, Nature and Rural Youth Clubs

Ungdommens naturvidenskabeligo Forening
(Young People's Union for the study of natural sciences)
Ill. Familie Journal,
Copenhagen, Valby, Denmark.

Luonto-Liitto,
(Federation of the Friends of Nature)
Kammionkattu, 9 A. 9,
Helsinki, Finland.

Société des Sciences Naturelles de l'Ouest de la France,
(Young Naturalists)
2, Rue Athénas, Nantes, France.

Nederlandse Jeugdbond voor Natuurstudie
(Young Naturalists)
Rustenburgerstr. 270,
Amsterdam, Netherlands.

Sveriges Faltbiologisk Ungsdomferening
(Swedish Field-Biology Youth Group)
Parkvagen 10B, Solna, Sweden.

Groupe des Jeunes de Nos Oiseaux
(French-Swiss Society of Young Bird-Lovers)
Saillon, Valais, Switzerland.

Amateur Weathermen of America,
Franklin Institute,
Philadelphia 3, Pa., U.S.A.

Audubon Junior Clubs are found in many countries. Information may be obtained from: National Audubon Society,
1000 Fifth Avenue, New York 28, N.Y., U.S.A.

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S.A. Alsina 500,
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ASSOCIATED STATES OF CAMBODIA, LAOS AND VIET-NAM
K. Chantarith, C.C.R.,
38 rue Van Vollenhoven,
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H. A. Goddard, Ltd.,
255a George Street,
Sydney.

AUSTRIA
Wilhelm Frick Verlag,
27 Graben,
Vienna I.

BARBADOS
S.P.C.K. Bookshop,
Broad Street,
Bridgetown.

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Librairie Encyclopédique,
7 rue du Luxembourg,
Brussels IV.

BOLIVIA
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Av. 16 de Julio 216,
La Paz.

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rua México 98-B,
Caixa postal 3291,
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4234 rue de la Roche,
Montreal 34.

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Colombo I.

CHILE
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Santiago de Chile.

COLOMBIA
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Carrera 9a, No. 1791,
Bogota.

COSTA RICA
Trejos Hermanos,
Apartado 1313,
San Jose.

CUBA
Unesco Centro Regional en el Hemisfero Occidental,
Calle 5 No. 306 Vedado,
Apartado 1350,
Havana.

CYPRUS
M. E. Constantinides,
P.O. Box 473,
Nicosia.

CZECHOSLOVAKIA
Orbis, Národni 37,
Prague, I.

DENMARK
Ejnar Munksgaard, Ltd.,
6 Norregade,
Copenhagen K.

ECUADOR
Casa de la Cultura Ecuatoriana,
ave. 6 de Diciembre,
Quito.

EGYPT
La Renaissance d'Egypte,
9 Adly Pasha Street,
Cairo.

FINLAND
Akateeminen Kirjakauppa,
2 Keskuskatu,
Helsinki.

FORMOSA
The World Book Co. Ltd.,
99 Chungking Rd.,
Section I,
Taipeh.

FRANCE
Librairie Universitaire,
26 rue Soufflot,
Paris-5°.

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Unesco Vertrieb für Deutschland,
R. Oldenbourg,
Munich.

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Elefthéroudakis,
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Athens.

HAITI
Librairie "A la Caravelle",
36 rue Roux,
Boîte postale III-B,
Port-au-Prince.

HUNGARY
Kultura, P.O.B. 149,
Budapest 62.

INDIA
Orient Longmans Ltd.,
Indian Mercantile Chamber,
Nicol Road,
Bombay.
17 Chittaranjan Ave,
Calcutta.
36-A Mount Road,
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Hornby Road,
Bombay I.

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Djalan Nusantara 22,
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McKenzie's Bookshop,
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Blumstein's Bookstores, Ltd.,
35 Allenby Road,
Tel Aviv.

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via Gino Capponi 26,
Casella postale 552,
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Peter Chong and Co.,
P.O. Box 135,
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Sapienza's Library,
26 Kingsway,
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South's Book Depot,
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McLeod Road,
KARACHI.
35 The Mall,
PESHAWAR.

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Agencia Internacional
de Publicaciones,
Apartado 2052,
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PANAMA, R.P.

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Libreria Internacional
del Péru, S.A.,
Apartado 1417,
LIMA.

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Case postale 72,
FRIBOURG.
Europa Verlag.
5 Rämistrasse,
ZÜRICH.

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Librairie Universelle,
DAMASCUS.

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Centre international,
54, rue du Statut.

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Suksapan Panit,
Arkarn 9,
Rajdamnern Ave.,
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Agence Aghlébite,
20 Grand-Rue,
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KAIROUAN.

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469 Istiklal Caddesi,
Beyoglu,
ISTAMBUL.

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Burma Educational
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Jugoslavenska Knjiga,
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IN THE DEVASTATED COUNTRIES

Prepared by J. P. STEPHENSON
(2nd ed.)

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